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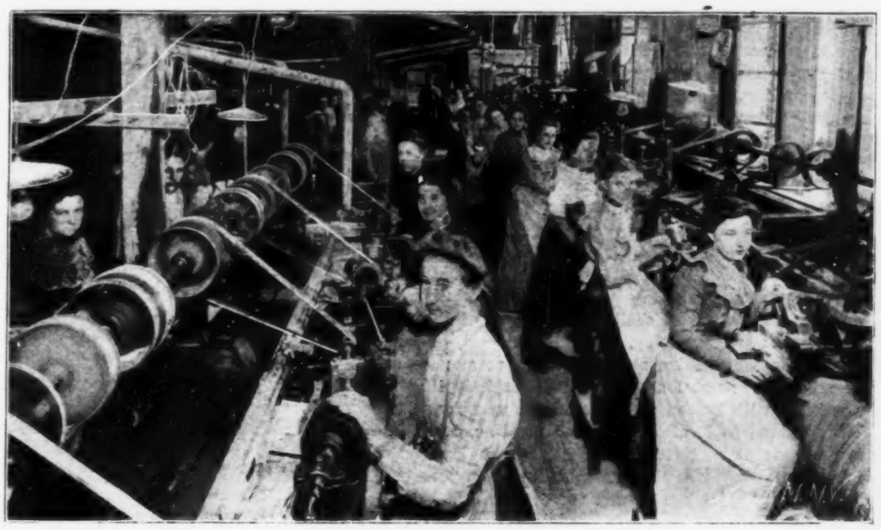
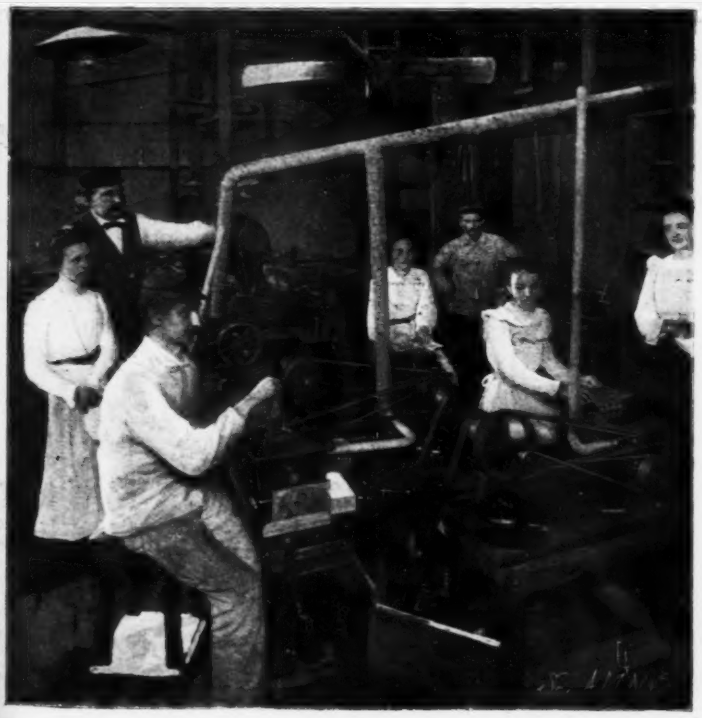
DIGGING SHELLS IN THE WHITE RIVER, ARK.

SHELL CAMPS IN ARKANSAS.

CUTTING THE BLANKS FROM THE SHELL.



SHAPING AND DRILLING ROOM.



AUTOMATIC DRILLERS.

CARDING AND SORTING ROOM.

THE MANUFACTURE OF FRESH-WATER PEARL BUTTONS.

FRESH-WATER PEARL-BUTTON INDUSTRY.*

AN IMPORTANT AMERICAN INDUSTRY.

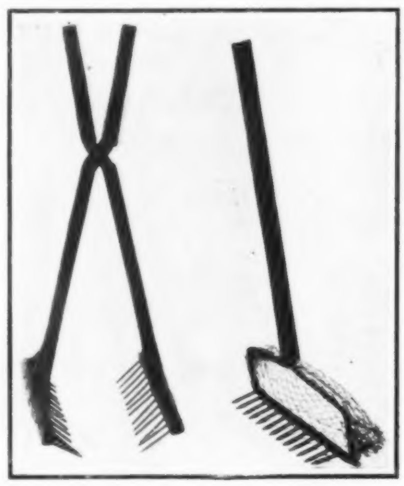
BY AXEL JOSEPHSSON.

THE most important branch of the button industry of to-day in the United States is the manufacture of pearl buttons. It embraces buttons made from mother-of-pearl and from the shells of the Unios, which are so abundant in the Mississippi River. In value the production of these varieties of buttons in 1900 formed 48.4 per cent of the product reported for the entire button industry. The making of buttons from mother-of-pearl was introduced into the United States on a small scale about 1855. At that time, and for many years thereafter, the shells were brought from China, but now the markets of the world are supplied principally from South Australia and from the South Sea Islands. The technical name for buttons made of mother-of-pearl is "ocean pearl," while those made from the shell of the Unio are called "fresh-water pearl" buttons. The higher grades of pearl buttons are still manufactured from the ocean shell, and the production of these far outranked that of all other kinds, constituting 30.2 per cent of the total value of buttons manufactured in the United States.

In 1890 there was not a single fresh-water pearl button made in the United States. In 1900 the making of these buttons constituted the second most important branch of the button industry. In Europe shells of the mussels found in rivers have been utilized for button making for the last fifty years. To Mr. J. F. Boepple, of Muscatine, Iowa, belongs the credit of having started the industry in the United States, and now it is the source of income for thousands of persons. In 1891 Mr. Boepple, who is a native of Hamburg, Germany, where he learned the trade of making pearl buttons, formed a partnership for the manufacture of buttons from the Unio, or "niggerhead" shells, as they are called locally, which were banked up for miles along the river in front of Muscatine. After experimenting for some time this concern found the business unprofitable and it was dissolved. Nothing daunted, Mr. Boepple continued making the buttons, on a small scale, at his home. He finally organized a company which, by the process of manufacture and machinery utilized in Austria and Germany, succeeded in making the enterprise a success. The tools needed in the manufacture of shell buttons were of the simplest character, consisting, for the most part, of turning lathes worked by steam or foot power; consequently it was not long before the Mississippi River was lined with button factories all the way from Red Wing, Minn., to Louisiana, Mo. Muscatine, Iowa, became the center of this new industry. A few years ago there were more than forty factories in that city for the cutting of blanks and for the making of buttons, but the tendency toward concentration has made itself felt, as has also the need of improved machinery and large capital to withstand the tremendous competition, and all along the river the smaller concerns are being eliminated. The difference in price between the ocean shells and the Unios has been an important factor in the development of the fresh-water button industry. A few years ago the mussel shells were delivered at the factories at about 50 to 60 cents per 100 pounds, while at the same time ocean shells were worth from $30 to $60 for the same quantity. In February, 1898, prices went up to $18 to $20 per ton for "niggerheads," but in July of the same year they were cheaper than ever before or since, selling at 30 cents per 100 pounds. The cheapest grade of ocean shells are the Panama, which sell at 10½ cents per pound.

The improvements in machinery in recent years have been so rapid that some manufacturers have exchanged their machines three times in three years, each time practically re-equipping the entire plants.

The following is a short *résumé* of the mode of making pearl buttons. After the mussels have been cooked and the meat removed, the shells are taken to the factories and stored in sheds. They are then sorted into three different sizes and soaked in barrels of water from three to six days to render them less brittle. They must be used while wet, otherwise they crumble under the saw. The next step is the cutting or sawing of the rough blanks. The shells are usually held with pliers while being cut, but some sawers hold them in their hands. The saws are hollow, cylindrical pieces of steel, 2 inches wide, and with a diameter corresponding to the size of the button. At one end these cylinders are provided with fine teeth; they are adjusted to lathes in which they revolve. As the sawyer holds the shell against the saw, the blanks are cut out and passed back into the saw and saw holder and drop into a receiver. The next step is the dressing or grinding of the back of the blank to remove the skin and make an even surface. To accomplish this, each blank has to be held with the finger against a revolving emery wheel. Then comes the turning, by which



TONGS AND RAKES USED IN MUSSEL FISHING.

the front of the button is given its form, including the central depression. When the holes are drilled the button is complete, with the exception of the polishing process, which brings out the natural luster which was lost in the grinding. It is this luster which gives the buttons their chief value. The polishing is effected by placing the buttons in bulk in large wooden tumblers or kegs, in which they are subjected to the action of a chemical fluid as the tumblers revolve. By mutual contact, combined with the effect of the fluid, the buttons become highly lustrous. Then they are washed, dried, and sorted into sizes and grades of quality. After being sewed on cards and packed in pasteboard boxes, the buttons are ready for the market.

The majority of the factories in the West do not finish the buttons, but merely cut the blanks. These are then sent to the factories in the East, which are supplied with improved machinery for the finishing of the buttons. Some of these Eastern factories for-

VALVE OF UNIO WITH "BLANKS" CUT OUT FROM IT.

THE MANUFACTURE OF FRESH-WATER PEARL BUTTONS.

merly made buttons out of imported mother-of-pearl shells, but now their principal work is the finishing of the home product.

Notwithstanding the enormous progress this branch of the industry has made during the last five years, it is yet in its infancy. The only disquieting circumstance is the injudicious and wanton depredation of the shell deposits. The beds in front of Muscatine, Iowa, are already exhausted, and unless something is done to protect the mussels it will not be long before the raw material for this industry will be exhausted.

* The material for this article was extracted from a monograph by Axel Josephsson, published in Census Bulletin 172.

PROCESS OF MAKING CREOSOTE OIL.*

MANY chemicals have been used for the preservation of timber, among them being blue vitriol, corrosive sublimate, and chloride of zinc. The most effective preservative is the substance called "creosote oil" or "creosote." On account of the similarity of the names, many people suppose this to be the creosote obtained from wood, such as can be obtained, refined for medicinal purposes, at the drug stores. But the two are quite different and should not be confused. The creosote used in wood preservation is obtained from coal, by a most interesting process. Nearly every city now uses gas for light and fuel, and many people know that this illuminating gas is often made from coal. But the many things besides gas which are obtained in this process are not so well known. It is one of these other products from which is obtained the creosote oil used for wood preservation.

To understand how all these things are produced, it is necessary to know something which the chemists can tell us. Coal, they say, is composed partly of the substance called carbon, and partly of compounds of this carbon with the gas hydrogen, which they have named "hydrocarbons." When the coal is heated sufficiently, away from air, the hydrocarbons are driven off in the form of gas. Illuminating gas is made by subjecting coal of the proper kind to this process, which is known as "dry distillation." The coal is put into a long, fire-clay oven, or "retort," shaped much like a giant model of the little cakes which the bakers call "lady fingers," the retorts being about thirteen feet long, two feet wide and sixteen inches deep. A number of these retorts are built side by side, in three rows, one above the other, the ends of the retorts being supported in a brick wall which also extends around the end of the rows and over the top, and thus entirely incloses the retorts. Fire from furnaces below is carried by flues into this inclosure, so that the retorts are entirely enveloped in flame and can be heated to a very high temperature.

The retorts are partly filled with coal, after which they are sealed, so that no air can get into them. They are then heated to about 2,100 deg. F. Under this intense heat almost all of the hydrocarbons of the coal pass off, leaving behind only the "fixed" carbon, which comes out of the retort as coke. Many of the lighter compounds distilled off by the heat will now remain in the form of gas when they are cooled to ordinary temperatures, and it is some of these which make the gas finally used for lighting and fuel. But as it comes from the retorts the gas is like a thick, yellowish-green smoke, and could not be used at all for such purposes. This gas escapes from the retorts into a series of large and costly machines where the lighting gas is cleansed from its impurities, and the different by-products are separated from each other. First are great "condensers" in which the gases are cooled. The cooling condenses the heavier compounds into thick liquids, which are then left behind.

One of the substances later removed from the gas is ammonia, and from such gas works comes the ammonia water which is used in every household. Another important product of the gas making process is the coke which is left in the retort. Every year an increasing number of people use this coke for burning in kitchen stoves, and even in furnaces, instead of coal, for it makes a very hot fire and burns without any smoke.

The heavy, strong smelling, black liquid which is collected in the cooling of the gas is what we know as coal tar. This is an exceedingly complex mixture of substances. From it are obtained not only creosote oil, but most of the dyes which are used nowadays, perfumes, and even flavoring extracts.

Gas, coal tar, and coke are also made in what is known as the by-product coke oven, which is adapted to different objects but is operated on the same principle. Its coal tar is equally as good as the gas works tar for making creosote oil. In recent years a great amount of gas has been made in the United States by another process, and is known as water gas.

* Spatula.

This process also produces a tar, which looks much like coal tar and is often difficult to tell from it. But this tar is really derived from petroleum, and does not make a good oil for preserving wood from decay. Wood creosote, with which so many people are familiar, is likewise obtained from a wood tar which is produced by distilling wood. But like water gas tar creosote, wood creosote is not so good for wood preservation as is the coal tar creosote. When creosote is bought for that purpose, therefore it should be certain that it is coal tar creosote.

To obtain creosote oil from coal tar the tar is, in its turn, distilled. But this distillation is like that used for other liquids instead of that employed for the coal. The still is heated, and as the heat increases the "light oils" first pass over. Among these is the familiar carbolic acid. This is a powerful antiseptic, but it is not desirable in a wood preservative, for it evaporates so readily that it soon becomes lost from the wood. When a temperature of about 400 degrees has been reached, the distillate is turned into another receiver, and from this point on to 600 or 700 degrees creosote oil is produced. One of the substances which is contained in this mixture is "naphthalene," from which common moth balls are made. Coal tar creosote, thus produced, is the great wood preservative.

The residue remaining in the still after the distillation is "pitch," which is used chiefly in the preparation of roofing felt. In America roofing pitch is the chief end for which tar is distilled. In Europe this is not so true. Now pitch for roofing must be rather soft. Therefore tar distillation is not carried so far in this country as it is in Europe. For creosote oil it would be better if it were carried farther, since the substances which distill at the higher temperatures, in most cases neither evaporate in the air nor dissolve in water as readily as those which distill more easily. Consequently they stay in the wood for a longer time, and protect it correspondingly longer from decay. Much study is being devoted by the United States Forest Service to creosote oil, to determine what its composition should be to give the best results in preserving timber, under different conditions, and how the most desirable creosotes may be obtained. The reports of these studies, together with detailed description of the more economical processes of applying the preservatives to wood, have been worked into circulars which the government has placed at the disposal of all users of timber and which will be furnished to all who make the request of the Forester at Washington.

FRICTION OF THE AIR.

SKIN FRICTION A FACTOR IN AERIAL NAVIGATION.

BY MAJOR B. BADEN-POWELL.

THE extent to which skin friction retards the motion of aerial vessels is one of very great importance to the designer of such contrivances, and yet it is a subject on which a considerable diversity of opinion exists.

According to the theory of the viscosity of air discussed by Clerk Maxwell, "the actual tangential force on a one-foot-square plane moving parallel to itself through the air at a rate of 100 feet a second is less than 1/50 of 1 per cent of the pressure on the same plane moving normally at this speed."

Langley ("Experiments in Aerodynamics") boldly states: "The friction of the air is inappreciable. This fact may be stated as the result both of my own experiments and of well-known experiments of others." Maxim, too, says (Century Mag., October, 1891): "The skin friction between the air and the polished surface is so small that it need not be taken into consideration, which is quite the reverse of what takes place with screws running in water." But later on, in calculating the power necessary to drive a given machine, he allows 10 per cent of total power to overcome (at 30 miles an hour) atmospheric friction.

Dines, in 1890, found the tangential component to be so small that it may be neglected. He also tried covering the surface of the plane he was experimenting with with sandpaper and with flannel, and it is noteworthy that his general conclusions were that the sandpaper made no difference in results, but that flannel, though not affecting the results when the surface was normal to the current, yet made considerable difference when it was inclined.

Kress, in a paper contributed to the International Conference on Aerial Navigation in 1893, says: "As to the friction of the air, it is known to be so small that it may safely be neglected."

Other investigators have calculated the skin friction of the air on the basis of that of water, and suppose it to be about one-eight-hundredth of the amount (that being the difference in the density of the two mediums). But it has to be remembered that such an assumption cannot be accepted without further experimental proof. Skin friction is due to viscosity, and viscosity varies with the fluid, independent of its density. Thus, while treacle is highly viscous, mercury, of far greater density, is much less viscous.

Froude, in his experiments on skin friction in water, found two important points which probably apply to air resistance. First that the skin friction was not exactly in proportion to the surface; that is, with a larger surface the skin friction was not so great relatively as with a smaller surface. Secondly, he found that the resistance did not increase as the square of the velocity, but in a somewhat smaller ratio, the mean result being a power of 1.92.

Prof. A. F. Zahm, of Washington, was probably one of the first to make any really careful and extensive experiments on air friction. *His conclusions were that "the frictional resistance is at least as great for air as water, in proportion to their densities. In other words, it amounts to a decided obstacle in high speed transportation. In aeronautics it is one of the chief elements of resistance."*

The apparatus which he used consisted of various planes suspended by wires in a wind-tunnel 40 feet long by 6 feet square. The air in the tunnel is driven along by a fan at any desired speed. The planes, placed edge on to the wind current, were driven back by it and the amount of motion duly measured. The difficulty was to eliminate the effects of end-thrust, and this was at first done by placing fixed wind shields in front of the edge of the plane. Corrections were duly made for the action of the air on and around the shields. Later, instead of the wind shields, prows of ogival form were attached to the planes and the resistance of these separately determined and deducted from the results. The planes were made of paper tightly stretched over a wooden framework. Other planes were of pine boards of varying lengths.

The results showed that, to take an instance, at 25 feet per second the friction on the sides of a 16 feet by 4 feet board amounted to 0.0026 pound per square foot, while at 37 feet per second it was 0.005, and the formula deduced was

$$f = 0.00000778\ l^{.93}\ v^{1.85}$$

f being the average friction in pounds per square foot, l the length in feet, and v the velocity in feet per second. This equation applied to all the velocities and lengths of surface employed. *It is very similar to that obtained by Froude for water, allowing for the relative densities.*

Trials were also made with various materials to observe the effect of quality of surface on the tangential resistance. Various varnishes and different kinds of paper and zinc all gave the same result, but with coarse buckram the friction at 10 feet a second was 10 to 15 per cent greater and increased approximately as the square of the speed. Glazed cambric has about the same friction as a varnished surface, but if the cambric is roughened, so as to expose a fine down, the friction is very much increased. Hence he concludes, "all even surfaces have approximately the same coefficient of skin friction. Uneven surfaces have a greater coefficient."

Though, in these experiments, no determination was made as regards the barometric density of the atmosphere, doubtless the friction would increase with the density.

Mr. Lanchester, in his recently published work on "Aerodynamics," discusses the question very fully, and, basing his arguments chiefly on results obtained in water, concludes skin friction to be an important consideration. His own experiments with little gliders of a few inches area seem, however, hardly conclusive.—Aeronautics.

OIL FUEL FOR SHIPS.

CONSUL JOHN L. GRIFFITHS makes the following report from Liverpool on the extending utilization of petroleum for ship propulsion:

The use of oil as fuel has engaged the attention of the British Admiralty for some time, and it has recently been decided to establish oil storage tanks in various parts of the United Kingdom to insure convenient sources of supply. Birkenhead, directly opposite Liverpool, has been selected as one of the supply centers. The experiments conducted by the Admiralty during the past twelve years were not at first satisfactory, and two adverse reports were made prior to 1902. Since then the tests have been of such a character as to reverse the original judgment of the Admiralty, and it may now be said that the importance of oil fuel is recognized by that body, and that its use will be extended in the future as rapidly as possible.

It is claimed that through the use of oil the number of men now required to do the stoking and trimming would be reduced by two-thirds, as the moving and stoking of the oil is automatically accomplished by steam pumps and pipes, instead of by stokers and trimmers as in the case of coal. While it is difficult with coal fires at full speed to maintain sufficient steam, it has been demonstrated that with oil fuel this difficulty would be overcome, and that when the speed of the ship is reduced the boilers are under such perfect control that the safety valves do not lift.

The oil, it is suggested, could be stored in the double bottom, now taken up by water ballast. In the case of the navy, one of the great advantages claimed for oil is the absence of a great volume of black smoke when vessels are proceeding at great speed, and which serves to give information to the enemy. The evaporative value of oil is much greater than that of coal, so that while 45 cubic feet of bunker space is required for a ton of coal, only 38 cubic feet is needed for a ton of oil. It will readily be seen how significant this difference would be to the great ocean-going steamers, and how much space now set apart in them for the storage of coal would be released for cargo purposes and the accommodation of passengers.

The British navy has in service oil-using torpedo boats with a capacity of 34 knots. One of the drawbacks at the present time to the extensive use of oil fuel at sea is the high cost and the difficulty in many instances of securing it. The cost of oil in Great Britain has no doubt seriously interfered with its adoption for steamships and for a variety of industrial purposes. With a reduction in price the field for its employment would be greatly enlarged. The advantages of oil fuel briefly summarized are economy of space, absence of soot and cinders, elimination of the loss of time consumed in burning down and cleaning fires when coal is used, the ease with which oil can be bunkered, and the quickness with which a full head of steam can be generated.

GINSENG IN NEWCHWANG.

IN reply to western ginseng growers, Consul-General Thomas E. Heenan, of Newchwang, furnishes the following information concerning the manner in which the American product reaches that Chinese port:

It is impossible to deal direct with the Newchwang ginseng merchants. This can be attributed to several reasons. Whatever American ginseng root has been imported into this port during the past has gone through a clarifying process at Hongkong before shipment. The local Chinese dealer in purchasing the American root at Shanghai and Hongkong, prefers that method to any other, as the entire transaction is between native firms, who fully understand the particular wants of the different communities, which would not, of course, be the case were foreigners interested in such transactions.

The clarifying at Hongkong is practically controlled by a trust, which regulates the market value of the clarified article, according to the supply and demand. On several occasions attempts were made to do the clarifying at Shanghai, but owing to the fact that the process is more or less secret and under trust control, in neither instance did the project result successfully.

During last year, for some unaccountable reason, no American ginseng appeared in the Newchwang customs import returns, and it is evident that whatever demand occurred was supplied by the root of Manchurian growth. American ginseng root was never used to any great extent by natives in Manchuria; the same can also be said of them in regard to the root of their own growing, which is exported to southern ports, where a large demand continually exists. The amount exported to the South during 1907 from Newchwang was more than $160,000, and consisted of native and wild, beard and refuse; the export of native growth being more than $120,000.

A NEW TYPE OF SEXTANT.*

A NOVEL AID TO NAVIGATION.

BY L. A. FREUDENBERGER.

The ordinary sextant (Hadley's) makes use of the well-known law of reflection—that the reflected and incident rays make equal angles with the normal to the mirror surface—in order to obtain a movement of a vernier arm of half the angle measured. The arc is graduated, however, to read the angle directly.

In the new type of sextant devised by the writer, the law of reflection, that the incident and reflected ray lie in the same plane, normal to the mirror surface, is taken advantage of to make the angular movement of the vernier-arm equal to the angle measured. The principle of the new type of sextant is substantially shown by Fig. 1.

A is a full silvered mirror, mounted with adjusting screws to make an angle of 45 deg. with the axis *M N* of the instrument. The mirror *A* rotates in the cone bearing *P* about the line of sight *M N* as an axis. A vernier-arm *C* (not shown in Fig. 1) is fastened to the frame *A* and moves over a graduated arc fastened to the frame of *B*, serving to measure the angle of rotation of the mirror *A* around *M N* as an axis. *B* is a half silvered mirror mounted with adjusting screws to make an angle of 45 deg. with the axis *M N*. In Fig. 1 the positions of the mirrors are shown for parallel rays (both mirrors reflecting an image of the horizon, which two images are brought in coincidence for the "zero" setting). If mirror *B* is kept sighted on the horizon, it is evident that with the sun at the meridian, mirror *A* will have to be rotated 90 deg. about the axis *M N* in order to reflect the sun's image down the line of sight.

Figs. 2 and 3 are photographs giving front and rear views of a sextant embodying the above principles, constructed by the writer, and in which the mirrors and accessories are clearly shown.

In the practical use of a sextant—sighting on the sun and the horizon, for instance—accuracy is limited by the difficulty the eye experiences in deciding when the sun's disk just touches the horizon. In the Hadley sextant, suppose that the eye can determine the coincidence of two images to within one minute of angular movement of the mirror surfaces. This means that the actual angle between the two objects can only be determined within *two* minutes of angular measure. In the new type of sextant (Fig. 1), let the coincidence of two images be determinable again within one minute of angular movement of the mirror *A* in Fig. 1. This means that the actual angle between the two objects can also be determined within a minute of angular measure. This possibility of increasing the accuracy of measurement is, of course, the sole advantage of the new type of sextant. The new type of sextant differs from the old in the following particulars:

The field of view in the new type of sextant appears precisely the same as in the Hadley type, except that in driving forward the vernier-arm the moving field of view travels through a vertical arc of a circle, while the moving field of view in the Hadley sextant makes a straight vertical movement.

Fig. 2.

In locating two objects (see Fig. 2), so as to make them appear in the field of view, the line of sight of the telescope is at right angles to the plane containing the two objects and the observer, i. e., the plane of the graduated arc of the instrument passes through the two objects. Vertical movements of the field of view are obtained by rotating the instrument as a whole about the line of sight of the telescope.

The Hadley type of sextant usually measures actual angles to 120 deg. of arc or more. Since the angular movement of the mirror is only half this the sector of the graduated arc is only 60 deg., though graduated to read 120 deg. directly. To secure an angular measurement of 120 deg. in the new type of sextant, it is necessary to have a graduated sector of 120 actual

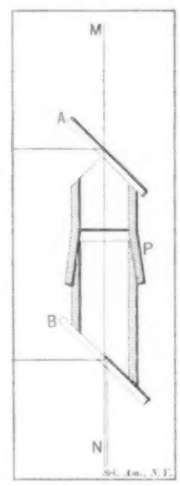


Fig. 1.

degrees. Strictly speaking, the new instrument can hardly be called a sextant, since the graduated sector subtends one-third of a circle instead of one-sixth.

The adjustments of the mirrors in the new type of sextant can be accomplished most easily at sea where a horizon is always available.

To adjust for "zero" reading, the movable vernier-arm is clamped at the zero reading of the graduated arc. Mirror *A* (Fig. 1) is then adjusted until the two images of a very distant object appear in coincidence. To test whether the mirror *B* is properly adjusted, the two images should remain in coincidence independently of which part of the field of view is used. On sighting on a very distant straight line (the horizon, for instance), want of proper adjustment of mirror *B* would be shown by the two horizon lines, though meeting for the "zero" reading, not forming a continuous unbroken line but being bent at the line of division of the half silvered mirror. If desirable, the graduations and arc may be extended to 180 deg. or even to 360 deg., when the adjustment of the mirrors may be exact, since the two horizon lines should coincide when the vernier-arm is set at 0 deg. and also when set at 180 deg. An angle and its supplement might thus be measured, in order to compensate for eccentricity errors of the graduated arc.

Delaware College, Newark, Del.

* Reprinted from the Physical Review, vol. xxvi., No. 3, March, 1908.

INVESTIGATION OF ILLINOIS PETROLEUMS.

The importance of a systematic comparison of the different varieties of crude petroleum occurring in the United States is receiving full recognition in the United States Geological Survey, where an examination of certain oils from the new Illinois field has just been completed.

In February of this year the Survey sent an agent into the Illinois field to collect representative samples of the oils, the localities being selected in conference with Dr. H. Foster Bain, the State geologist. These samples were shipped to Washington, where they were examined by Dr. David T. Day, who has charge of the oil investigations. The samples were examined as to odor, color, and specific gravity, and then distilled by the Engler distillation apparatus, the quantity distilling up to 150 deg. C. being classed as naphtha, and that between 150 deg. and 300 deg. C. as burning oil. The determination of the sulphur content of the oils was made in the Pittsburg laboratory of the Survey.

The methods used in these oil tests have been selected because of their simplicity, which enables them to be carried rapidly to completion, and the treatment of all the samples in precisely the same manner affords a basis for a just comparison of the oils. In the first series of tests oils from 34 pools were examined, and tests on 104 samples collected in April in the Mid-Continent field are now under way.

The oils range in gravity from 39.5 deg. B. in the deep wells (1,500 feet) in the Bridgeport pool to 22.3 deg. B. in the Duncansville pool. Some of the shallow wells (300 feet) in the north end of the field also yield oils as light as 35.5 deg. B.

No oil was found with more than half of 1 per cent of sulphur, and this only in the extreme north end of the field. Farther south the average is about one-fourth of 1 per cent and the oils are acceptable as non-sulphur oils. Pipe-line samples from all pools averaged still less—that is, 0.2 per cent.

The percentage distilling below 150 deg. C. ranged from 1 to 21, averaging 13.2 per cent for the State. The burning oil averaged 31.2 per cent.

Most of the oils contained practically no asphalt and considerable proportions of paraffine wax.

COMPOSITION FOR PRESERVING FURNITURE.

Take a few pieces of wax—white or yellow—and add sufficient turpentine to give the solution the consistency of a thick paste. Put a piece about the size of a bean on a cloth and spread it on the furniture, rubbing the latter afterward with a woolen rag. The polish may be restored to walnut furniture, marble, or varnished metals in this way. If, however, it is desired to use the compound for articles having a red color, the turpentine oil must be colored, before adding the wax, by steeping a little alkanna in it till it becomes a deep violet. To restore the polish to mahogany, the oil must be only slightly colored, as this wood has the property of becoming brown with time; bird-cherry wood, on the other hand, bleaches after a time; when used for this wood, therefore, the oil should be given a strong color. It should be noticed that only a piece of the composition the size of a bean should be applied; if more is used, it will be necessary to continue rubbing for a long time, hence it is better to apply a second thin coating and to repeat the operation several times. This takes more time, but is not so tiring and gives a better polish. After rubbing with a woolen rag, it is advisable to rub once again with an old linen rag.

HOTBEDS WITHOUT GLASS.

You can save $3 and have vegetables a month earlier than your neighbors by making a hotbed with a paper or muslin cover instead of buying glass. Seeds do not require light for germination, but the young plants will become spindly and tender unless you give them as much light and air as possible. The cover of a hotbed is only to protect the young plants from cold. Prof. Bailey tells in his "Horticulturists' Rule Book" four ways of preparing the paper or muslin:

1. Use a sash, without bars, and stretch wires or strings across it to serve as a rest for the paper. Procure stout but thin Manila wrapping paper and paste it firmly on the sash with fresh flour paste. Dry in a warm place and then wipe the paper with a damp sponge to cause it to stretch evenly. Dry again and then apply boiled linseed oil to both sides of the paper and dry again in a warm place.

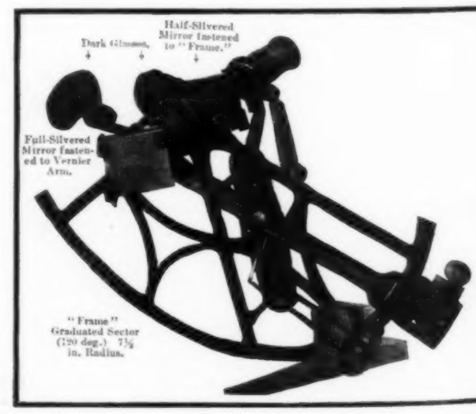


Fig. 3.

2. Saturate cloth or tough, thin Manila paper with pure raw linseed oil.

3. Dissolve 1¾ pounds white soap in one quart water; in another quart dissolve 1½ ounces gum arabic and 5 ounces of glue. Mix the two liquids warm and soak the paper, hanging it up to dry.

4. Three pints pale linseed oil; 1 ounce sugar of lead; 4 ounces white rosin. Grind and mix the sugar of lead in a little oil, then add the other material and heat in an iron kettle. Apply hot with a brush to muslin

AUTOMATIC CAB-SIGNALING ON LOCOMOTIVES.*

BY J. PIGG.

Of late years the subject of the signaling of railways—that part by which instructions are given to the drivers of trains—has received a good deal of attention, and the difficulties under which drivers labor under exceptional conditions of weather have long been recognized. A number of systems have been devised and put forward for supplementing the ordinary outdoor mechanical signals but, practically, no progress has been made in their application. Many of the suggestions have obviously, from internal evidence, been made by persons having little or no knowledge of the conditions to be satisfied in railway working, and are impracticable by reason of the arrangements proposed; others are impossible because of the expenditure involved, and some, again, could not be adopted because they involve departures from the regulations under which traffic has to be worked. Some projects have been of a most ambitious character; in others the designers have been content with the simplest possible indications. In some cases the apparatus has been purely mechanical, in others purely electrical, and in others, again, a combination of the two has been made use of. In certain cases the indications are to be given directly upon the engine, in others they are to be produced on the line, but to be of such a character that they could not fail to be noted by the driver in the opinion of their designers. In some cases visual indicators are provided, in others audible signals are given, and also a combination of the two is suggested. In certain proposals indications are to be obtained by direct impact between apparatus carried upon the engine and other apparatus fixed on the line; in other proposals impact is lessened by the use of brushes sliding over prepared surfaces, and some contactless systems, depending for their action upon magnetic influence, have been proposed. Whatever the merits of the various proposals, not one has made any headway toward adoption, and railways still continue to use the system of visual signaling—during clear weather—supplemented by the audible, explosive signal during fogs, etc., with which all are familiar, notwithstanding its admitted deficiencies, and the lessons taught from time to time by accidents of a grave character. This delay cannot, however, be laid to the charge of the railway companies who have on many occasions furnished opportunities for the trial of apparatus, but whose officers have, necessarily, to gage carefully the merits of proposals from every standpoint.

The problem to be faced is not a simple one. There are many factors to be taken into account which render the designing of a system a matter of some difficulty. The engineering difficulties are evident when consideration is given to the speeds at which trains travel at the present day. At high speed the time allowable for the collection of a signal, by any reasonable design of apparatus, is very short, and the apparatus must be exceedingly prompt in operation. Where mechanical impact is relied upon for the operations, the stresses to which the parts brought into contact are subjected are tremendous, and in such forms as have been used, sooner or later, according to the frequency of use imposed by the design of the signaling apparatus as a whole, flaws develop in the stoutest material, and consequent failure. In all forms of actuation involving mechanical contact between parts on the engine and parts on the line, the greatest possible care must be taken to minimize the blow experienced.

The financial difficulties connected with such proposals are no less evident than the engineering difficulties. The requirements in connection with signaling have extended so marvelously, of late years, that its maintenance is likely to become a severe tax on railway companies. Any system of supplementing the present signaling which does not take into account the cost factor will fail in a most important point. If the proposals hold out any prospect of relief in this respect so much the better. It is comparatively easy to devise means to almost any end if cost is immaterial. The engineer's object, however, should be the keeping of the cost within the value of the service given. Certain things must be provided for railway operations—as in other industrial concerns—regardless of cost, and signaling is one of those, but the expenses incurred fall in the end upon the customer. Railways, however, are in a position in which it would be difficult to maintain increased charges to cover increased expenses of operation. The public would, without doubt, oppose any increase of charges, even if they were incurred for the further guarantee of their safety when traveling.

If we carefully consider the operations involved in that mass of conventions known as the "block system" (in which term is included all apparatus used for signaling), we find that the sole aim of that complex system is the exhibition of appropriate signals to the drivers of trains for their guidance, and that it implies implicit observance on their part of the signals exhibited. We further find that while the signalmen, by whom the driver is guided, are provided with reminders and hedged about with restrictions on their actions, the driver must rely upon his physical powers—sometimes under most difficult conditions—to enable him to observe and obey the signals by which he is to be guided. We find also that, whenever accidents have taken place due to errors of signaling, they have had their origin in variations of one main cause—the human element of control and operation which is the basis of the system. Man has many more interests than those appertaining to any one task he may undertake, and to carry out any work requires more or less exclusive concentration of the mind upon its details. Probably nothing is more difficult for the average man to accomplish than to concentrate his attention exclusively upon one subject for any length of time; his other interests will rise in his mind, and engage his attention unbidden, and especially is this the case if his other duties are of a routine character and monotonous. Only in so far as a man is able to concentrate his attention on his immediate duties is he efficient for the performance of those duties. This want of the ability to concentrate the mind has been described variously as "absence of mind," "forgetfulness," "momentary aberration," and "neglect of duty." The name applied depends greatly upon the results following display of this human characteristic: in one case it may furnish the theme for a jest, in another it may result in a railway disaster. The results depend upon the surroundings. The characteristic, however, is the same in all cases.

There are three men concerned in the passage of a train past any signaling point; the signalman at that point who controls it by the mechanical signals, the signalman at the next signaling point ahead, from whom the former takes instructions before allowing the train to pass forward, and the driver who must obey the signals exhibited.

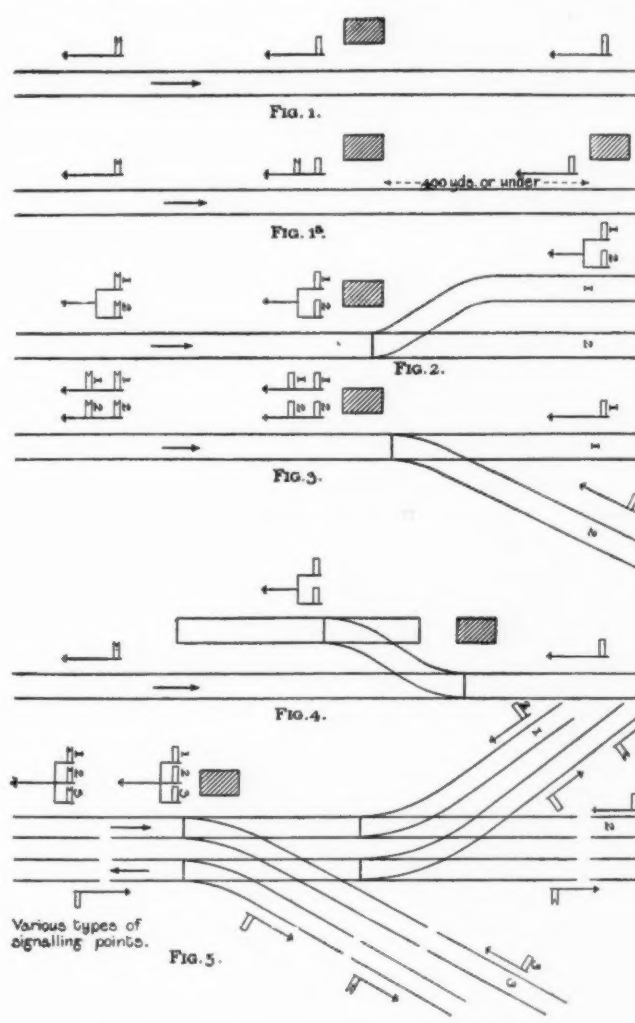
A study of the causes of railway accidents will show that each of these men has failed in his duty, and collisions have been caused by:*

(*a*) The signalman at the receiving end of a section giving permission for a train to enter the section before it is clear of the preceding train.

(*b*) The signalman at the sending end of a section allowing a train to enter the section before he has obtained permission to do so.

(*c*) The driver of a train ignoring the signals exhibited for his guidance at that point.

If we carefully consider these causes, it will be seen that they show the driver to be by far the most important of the three men engaged. Errors on the part of the signalmen *may* be neutralized and disastrous consequences obviated by the vigilance and promptitude of the driver; but if the latter acts under misapprehension, and ignores the guidance provided for him, there is no power capable of averting the consequences that may follow from the conditions obtaining at the point at which the error is committed, or subsequently, before he again comes under control. The driver, then, is the pivot of railway signaling, and it is of the utmost importance that every means should be taken to insure his duly receiving the guiding instructions provided for him. During the last two years the author has been associated, in a minor part, in experiments having in view the best means of supplementing the ordinary signals given to drivers. The apparatus has been designed by Mr. Vincent Raven,



FIGS. 1-5.—VARIOUS TYPES OF SIGNALING APPARATUS.

AUTOMATIC CAB-SIGNALING ON LOCOMOTIVES.

* Abstracted from an address before the Newcastle Section of the Institution of Electrical Engineers.

the Chief Assistant Mechanical Engineer of the North-Eastern Railway. The system is essentially an electrical one, which aims at reproducing, in the cab of the locomotive, all the information that the driver now obtains from the present mechanical signals, but is not intended as a substitute for those signals. Before proceeding to describe the apparatus, however, it may be advisable to look a little more closely than is usually done into the characteristics of the outdoor mechanical signals, in order to ascertain what is required from an efficient form of cab-signaling, and to compare the results obtained with the apparatus put forward for the purpose.

Consider the signals provided for main-line work, with which alone this paper deals. The principal signals are the "distant," the "home," and the "advance," the relative positions of which are shown by Figs. 1 to 5. The "distant," as its name implies, is fixed at a considerable distance from the box from which it is operated. It is the first signal belonging to the signaling point from which it is operated reached by a train approaching that point. The "home" signal is placed in the immediate neighborhood of the signal box, and so as to protect any points which may be situated there, and the "advance" is placed at some distance ahead of the signal box in the direction in which trains pass toward the next signaling point.

Signals may be divided into "stop" and "non-stop" signals: the "home" and "advance" signals are "stop" signals in that drivers must not pass them when at "danger"; the "distant" signal is a "non-stop" signal inasmuch as the driver is not required to stop at it when at "danger."

The principal indications given by semaphore signals are "on" and "off," indicating "danger" and "line clear" respectively, and the positions are the same for both "stop" and "non-stop" signals. In this respect the indications represent "condition of line" signals. A distinction, however, must be drawn between "stop" and "non-stop" indications of this character. The cautionary character of the "non-stop" distant when "on" has already been alluded to. When "off" the information given to the driver is fuller than that given by a "stop" signal in the same position, inasmuch as the interlocking between the points and signals, at any signaling point, is such that the "distant" cannot be lowered to "off" unless the succeeding "stop" signals have also been lowered. Hence a driver, when passing a "distant" signal which is "off," is assured that the "stop" signals are also "off" and the road is clear into the next section. If the signal is "on" he knows that the road is not clear, and he must be prepared to stop at the "home" signal. Hence the "distant" signal may be considered as *an indication at a distance* of the "condition" of the "stop" signal.

In addition to this characteristic of the "distant" signal, it is a "position" signal, in that it marks to the driver his position relatively to the signaling point he is approaching, and is to that extent a warning of his position. "Stop" signals are also "position" signals, but of a different character, in that they represent position which must not be passed when they are at "danger."

A further characteristic of semaphore signals, common to "distants" and "homes," is also shown by Figs. 2, 3, and 5. As will be seen, there are as many "distants" and "home" signals as there are diverging lines at the junctions, and that the signals are erected in the same order, relatively to each other, as the diverging lines are to each other. Thus: "distant" "1," and "home" "1," refer to line "1," and so on. Hence the "distant" and "home" signals for a diverging junction are "route" indicators in addition to their other characteristics. The duplication of signals shown on Fig. 3—one high up on the post and the other lower down—is intended to allow the driver to see the high signals at as great a distance as possible in clear weather, and the lower signal is to facilitate his observing the indications exhibited when weather conditions do not admit of his seeing the higher signals.

The time when the driver most urgently requires supplementary indications is undoubtedly during fogs and snowstorms, but it by no means follows that it is only during such exceptional conditions of weather that supplementary indications are of value. The history of railway accidents is not without cases where absence of mind of the driver has resulted in serious disaster in clear weather, and there have been other cases in which it has been strongly suspected that absence of mind has been the principal cause. Apart from this, however, the need for additional means of signaling during fogs, etc., is sufficient. No more strenuous duty can be imposed on a man than the driving of a 100-ton engine, with from 250 to 350 tons behind him, at a speed of 60 or 70 miles per hour, through a gray wall which never seems to end, where sight is useless, and on the rack with the endeavor to keep track of his position by the "feel" of the road, and for the explosive signal which means for him the "danger" signal—the only practicable signal given to him. Special arrangements have to be made for giving the present supplementary explosive signals, but instances are not unknown where they have broken down with lamentable results.

Many suggestions for providing supplementary indications have been made during the last twelve or fourteen years, most of which have had as their object the giving of the indications directly on the engine, in the cab where they are most easily observed. Others, however, have aimed at producing a signal, ordinarily an audible signal, on the line.

The latter are merely variations of the present supplementary explosive signal, with the added disadvantage that they are not so readily heard. Much of the efficiency of the explosive signal is due to transmission through the body of the engine. The difficulty of conveying sounds from the line to the cab of an engine, running at a high speed, under ordinary circumstances is so great as to render such systems totally useless. Cab-signaling is undoubtedly the only method worth consideration.

The choice of means by which the indications shall be given is limited, and to all intents and purposes lies between the adoption of visual or audible signals, or a combination of the two. Purely audible signals leave no record; and purely visual signals need considerably more attention than the driver can easily give. With the first he may forget *which* indication he obtained after it has ceased, either automatically or by his own action; with the second he may forget to observe it. From these considerations, alone, it seems imperative that both classes of signal should be employed, the audible signal being of the nature of an alarm, or "call attention" signal, and the visual signals giving the "condition of line" signals, and "route" indications.

The design of the apparatus divides naturally into two parts—that of the indicating apparatus, and that by which the indications are to be produced. The conditions to be satisfied in either class are not easily overcome. The indicating apparatus will be subject to violent vibration whatever arrangements are made, and must be capable of withstanding it. The means by which the indications are produced, if a contact system is used, will necessarily be subject to severe shocks, and must be strong. Purely mechanical apparatus for producing the indications, depending as it does upon impact, involving movement of some part against a resistance, has small chance of adoption on account of liability to failure under the stresses sustained, and the difficulty of operating such devices at the distances rendered necessary by the high speeds of trains. Where "off" signals are to be given, the cumulative effects of the multiplied blows would render such apparatus liable to constant failure. Moreover, mechanical systems, at their best, can never hope to reproduce in the cab, under the driver's immediate notice, all the information he obtains from the line signal.

The use of electricity offers much greater advantages, and enables the effects to be produced at any required distance from the operator without effort. The combinations that may be made with a given apparatus are more numerous, and the methods in which electricity can be utilized preclude the necessity for the violent shocks which are almost inseparable from purely mechanical operation. Nevertheless mechanical means may, if designed with a knowledge of the conditions to be met, be made to form a valuable auxiliary to electrical systems.

The collection of signals on the engine is a matter of the highest importance in any system of cab-signaling. In purely mechanical systems, as has already been stated, this is done by contact of apparatus carried on the engine, and apparatus fixed on the line which partakes more or less of an impact or blow. This blow may be minimized to some extent by the adoption of yielding devices on the engine or track, or by applying the contact more or less gradually by sloping devices, but the effects are but slightly reduced owing to the extremely short time during which the contacts are made, with any reasonable length of slope, etc., when trains are traveling at high speeds, and the effects are enhanced when heavy bodies are brought into contact by their inertia, and by strong control.

Electrical systems have generally to provide some form of mechanical contact between the circuits on the engine and those on the track, but as they do not necessarily involve the movement of the apparatus, their design need not follow the same lines. If efficient contact is established that is sufficient. The collection of currents from the track has other points, however, which need to be considered. Metallic contact is necessary, and it has been thought that under the conditions of use snow and ice, or dirt, might form an objection by causing failure to make efficient contact. In any system whatever the design is the most important point. If the apparatus brought into contact is not such as will tend to clean, but rather to press and consolidate whatever the bar may be covered with, failure is sure to result.

Considerations like these have given rise to suggestions for contactless systems of collecting indications, of which Mr. W. S. Boult's system is perhaps the best known. These systems depend upon magnetic influence for the operation of the signaling apparatus on the engine, and are therefore independent of such conditions as have to be provided for in contact systems.

Having reviewed the conditions under which signaling is carried out and the characteristics of the various signals, it will be gathered that the "distant" signal is one of the greatest importance, since at that signal the driver gains information by which he is guided in his immediate subsequent actions. At that point he is informed of his position relatively to the stopping place of that signaling point, and he there obtains the "condition of the line" and "route" indications if the line has been prepared for his further passage. What is required, therefore, in any supplementary apparatus is that it shall advise the driver, when he is passing a position corresponding to that fixed upon as the distant signaling point, of the condition of the "stop" signals in advance. If this is done, the driver is informed on all the points which it is necessary for him to know. From what has been said it will be seen that the following points should be provided for:

1. The first useful operation is to inform the driver, by way of warning, of his position relatively to the signaling point he is approaching, at such a distance as will enable him to carry out any steps necessary.

2. To advise him immediately afterward of the condition of the "stop" signals he is approaching, i. e., whether they are "on" or "off."

3. If the "off" signal is obtained it should be accompanied by a "route" indication, which will enable him to judge whether the right road has been prepared at a diverging junction. It should be possible to reverse this indication at some point or points before the train passes the "home" signal, in case of emergency, just as it is possible to reverse an indication with the mechanical signals by throwing them to "danger" before they have been passed.

4. If the "on" signal is obtained, the indications on the engine should be maintained until the "off" signal is received. It should be possible to receive the "off" signal at some point or points between the "distant" signaling point and the "home" signal to prevent unnecessary delay, just as the driver is able to note the lowering of the signal before he arrives at it by the projection of his vision in clear weather. It should be possible for the apparatus to indicate to the driver at some point or points how far he has traveled between the distant signaling point and the stop signal when the indication continues at "on." It should be possible for the driver to obtain the "off" indication when standing at the "home" signal. It should also be possible to give a signal to a train standing at the "home" signal which would be of a cautionary character and distinguishable from the ordinary authority to proceed.

As corollaries, the following conditions should also be provided for:

(*a*) The indication required under (1) i. e., the "warning" signal, should be given by the natural operations of the apparatus, and should require no action on the part of the driver or signalman to bring it into operation.

(*b*) The "condition of line" and "route" signals required under (2) should be under the sole control of the signalman, should be subject to the control imposed by the interlocking, and must be such that failure shall not be liable to give a dangerous false indication.

(*c*) The signalman shall be provided with indicators which will show him that the apparatus on the line for giving the signals on the engine is in order, and that the apparatus prepared is in accordance with the positions of the signal levers.

(*d*) The apparatus on the engine should be of a reliable character, easily seen and heard, and such that the indications shall, as far as possible, correspond with the apparatus it is intended to supplement. It should be self-testing and be continually in use, so that failure may be instantly indicated, and it should be so arranged that attention can be readily given and defective apparatus easily removed and replaced.

(*e*) The apparatus should be capable of easy adaptation to single or double line working.

(To be continued.)

According to an official of the United States Forest Service, 100,000,000 sleepers were used by steam and street railways in 1906 in the construction of new track and renewals. The average price paid was 50c. per sleeper. Approximately, three-quarters of these were hewn and one-quarter sawn. Oak furnished more than 44 per cent, while southern pine contributed about one-sixth. Other timbers used were Douglas fir, cedar, chestnut, cypress, western pine, tamarack, hemlock, and redwood.

MATHEMATICAL PRODIGIES.*

MANY EXAMPLES OF THE PRECOCIOUS.

BY FRANK D. MITCHELL.

WHATEVER the influence of heredity in some cases, it is in no sense an *explanation* of mental calculation, but at most a favoring circumstance. A satisfactory theory must rest on a much more definite basis than such general terms as heredity, environment, and the like can afford; it must explain the cases where hereditary influence is lacking, as well as those where such influence seems to be present.

There is nothing more striking about the mathematical prodigies, nothing which has been the subject of more uncritical amazement, than their almost uniform precocity. Gauss began his calculations before he was 3 years old; the present writer, at 4; Ampère, between 3 and 5; Whately, at 5; Pugliese and Succaro, at about 5; Colburn, at 5; Safford, at 6 or earlier; Mathieu le Coq, Mr. Van R., of Utica, Bidder, Prolongeau, and Inaudi, at 6; Mondeux, at 7; the Countess of Mansfield's daughter, at 8 or earlier; Ferrol, Mangiamele, Grandmange, and Pierini, at early ages not definitely stated. Dase attended school at the age of 2½, and took to the stage at 15.

To understand this precocity we must note, first of all, that arithmetic is the most independent and self-sufficient of all the sciences. Given a knowledge of how to count, and later a few definitions, and any child of average ability can go on, once his interest is accidentally aroused, and construct, unaided, practically the whole science of arithmetic, no matter how much or how little he knows of other things. Addition is only a shortened form of counting. The same is true of multiplication. Involution is simply a modification of multiplication; it has already been pointed out that the powers of numbers are natural resting-places in counting along the series of multiples of the numbers. The inverse operations of division and evolution grow naturally out of the direct operations of multiplication and involution; much more easily and naturally in mental than in written arithmetic. Once these elementary operations are mastered, such processes as reduction of years to seconds, compound interest, and any other arithmetical problems are simply a matter of understanding the meaning of the question and then applying known rules, plus a varying amount of ingenuity, to the solution. In accordance with the tendency of all mental operations, psychological shortenings of the processes involved will come with practice, and mathematical properties of the sort already described still further facilitate the work; so that in favorable cases the whole process may become in large measure automatic, and may go on while active attention is given to something else.

Moreover, the various symmetries and properties of numbers and series attract the attention of the calculator from the start, and keep up his interest until the habit of mental calculation has been firmly fixed. After that, if nothing intervenes to change that interest, there is no limit to which he may not attain.

We must note, furthermore, that practically an unlimited amount of time may be available for these calculations if the prodigy wishes so to use it. Mental arithmetic requires no instruments or apparatus, no audible practice that might disturb other members of the family, no information save such chance scraps as may be picked up almost anywhere for the asking, or absorbed, without even the trouble of asking questions, from older brothers and sisters as they discuss their school lessons. The young calculator can carry on his researches in bed, at the table—if he allows himself to be "seen and not heard"—during the perhaps laborious process of dressing or undressing; in short, at almost any time during the twelve or fourteen hours of his waking day, except when he is engaged in conversation or active physical play.

Thus, if an interest in counting once takes hold of a child either not fond of play or not physically able to indulge in it—and stringing beads, counting the ticks of a clock, or even a chance question like "Let's hear if you can count up to 100," may start such an interest, which will then furnish all the material for its own development—he may go on almost indefinitely, and become a prodigy long before his parents suspect the fact. Indeed, the interest in counting may seem so natural to the child that he may never think of doubting that every one else possesses it, and months or even years may elapse before some accident reveals the direction of his interest to his astonished relatives. Several of the calculators—Mondeux, Mangiamele, Pierini, Inaudi—were shepherd boys, an occupation which, since it requires an ability to count and affords ample leisure, is peculiarly favorable for practising calculation; several, again—Grandmange (born without arms or legs), Safford, Pierini, the present writer—were sick or otherwise incapacitated for active play to a greater or less extent, and thus enjoyed an equally good opportunity to practise calculation. Fuller and Buxton, on the other hand, whether precocious or not, were men of such limited intelligence that they could comprehend scarcely anything, either theoretical or practical, more complex than counting; and their purely manual occupations left their minds free to carry on almost without limit their slow and laborious calculations.

These considerations put the whole matter of mathematical precocity in a new light. Instead of joining in the popular admiration and awe of these youthful calculators—and even psychologists have not been wholly free from this uncritical attitude—we must say that precocity in calculation is one of the most natural things in the world. If a person is to become a calculator at all, he will usually begin as soon as he learns to count, and in most cases before he learns to read or write; and his development, while it will of course be gradual—in Bidder's case probably a year elapsed between his learning to count and the early incidents which made his gift known—will be so greatly facilitated by the amount of time available, the intrinsic interest of calculation, and the ease with which new information can be picked up as needed, that he may become a full-fledged calculator before he is suspected of being able to count without the aid of his fingers. His preoccupation with his calculations may give rise to a false appearance of backwardness, or he may really be of very low intelligence, or he may be an all-round prodigy like Safford, Gauss, and Ampère; mental arithmetic is so completely independent and self-sufficient that it is equally compatible with average endowments or with either extreme of intelligence or stupidity.

Mathematical precocity, then, stands in a class by itself, as a natural result of the simplicity and isolation of mental arithmetic. There is nothing wonderful or incredible about it. The all-round prodigy like Ampère, or Sir William Rowan Hamilton, or Macaulay is possible only in a well-to-do and cultured family, where books are at hand and general conditions are favorable, and he must possess genuine mental ability. The musical prodigy, again—Mozart is the stock instance—must come of a musical family, hear music, and have at least some chance to practise, and hence cannot long hide his light under a bushel. But the mathematical prodigy requires neither the mental ability and cultured surroundings of the one nor the external aids of the other. He may be an all-round prodigy as well, like Gauss, Ampère, and Safford; it is not improbable that Bidder, under favorable conditions, would have developed into such an "infant phenomenon"; but he may also come of the humblest family, and be unable, even under the most favorable conditions, to develop average intelligence. He may proclaim himself to the world almost at once, like the all-round or the musical prodigy, or keep his gift a secret for months or even years.

Mental calculation, then, starts from an interest in counting; at the outset it demands only that ability to count by 1's, 2's, 3's, 7's, and the like, which all of us require for such every-day purposes as keeping track of the days of the week. But if for any reason this interest in counting is lost, practice in calculation will cease, and the skill already acquired will disappear, just as the pianist's skill is lost when interest and practice cease. Here, again, however, there need be no mystery; the disappearance of the gift with the loss of the interest in which it originated is as natural and normal as its original appearance.

Just what caused the loss of interest is not always easy to say. In Whately's case the trouble may have been that on going to school he was taught arithmetic or "ciphering" by methods very different from his old ones, became confused, failed to establish a connection between the two, and lost his interest in calculation as a result of his distaste for "ciphering." In Colburn's case the loss of skill seems to have been much more gradual, and probably never complete. In this respect he is like the pianist who retains his interest in music, but is prevented by other occupations from keeping in practice; if later on he is able to resume practicing, his skill is soon regained.

Education as such, whether mathematical or general, has little or no influence on the calculating power, either to help or to hinder it. At the one extreme we find Fuller and Buxton, men of dense ignorance and limited powers of calculation, and near them Dase, the greatest of all calculators, who even in mathematics was scarcely less stupid. At the other extreme stand Ampère, Gauss, Bidder, and Safford, in whom unusual mathematical and general ability and a wide range of interests exist side by side with marked skill in mental calculation; while, on the other hand, the ordinary mathematician or man of culture has little or no gift for mental arithmetic. That the calculating power should be independent of general education is not particularly surprising; but its independence of mathematical training and ability seems at first less natural and obvious.

In a general way, we may distinguish three grades of mathematical ability in the great calculators. Those of the first class never get beyond the stage of pure counting, though of course the counting process comes to be abbreviated more or less with practice. At this stage the point of view is not even arithmetical; the calculator thinks not of arithmetical operations, but of properties of numbers and of series, and the short-cuts he uses are of a relatively simple sort, showing no mathematical insight. Without insisting too sharply on the distinction, we may term these men "calculating prodigies."

Those of the second class may be called, from the present point of view, "arithmetical prodigies"; Colburn and Dase will serve as examples. Here we find a fairly well developed knowledge of arithmetic, and a distinctly arithmetical point of view; it is operations of calculation, rather than mere properties of numbers, in which these men are interested, and the various short-cuts used are, we may suppose, suggested by practice in calculation rather than by mathematical keenness.

The third class comprises the "mathematical prodigies" proper, of whom Bidder may be taken as the type. Here we find real mathematical ability, power to take a distinctly algebraic point of view, to generalize, and hence to discover all sorts of ingenious short-cuts and symmetries. Bidder's compound interest method is perhaps the most striking example; Mondeux's unconscious use of the binomial theorem is another.

Such a classification must not be taken too seriously, of course; a good deal of hair-splitting would certainly be needed to establish hard and fast lines between the different classes. The important point is that mental calculation and mathematical ability are essentially independent, and that almost any degree of the latter is compatible with any degree of skill in the former. Where the two are found together, calculation usually appears first; but even to this there are exceptions, since Diamandi excelled in mathematics at school for nine years before he discovered his gift for calculation.

Neither mathematical nor general education or mental ability, then, has any direct influence on mental calculation. Indirectly, however, education may have an important influence. We have seen that if for any reason the interest in calculation is lost, the calculating power will disappear. Now mental calculation is a narrow and special field, with little practical importance for most men; hence, other things being equal, as a boy's sphere of interest widens, his interest in mental calculation is likely to sink into the background. This explains why so many ignorant men have excelled as calculators; ignorance, by preventing the intrusion of other interests, leaves the calculator free to develop his one gift, and keeps him from realizing how trivial it is, and how groundless is the public amazement which, perhaps, contributes to his support. On the other hand, if the interest in calculation is retained despite the widening of the sphere of interests resulting from education, the calculating power may prove to be of considerable practical value. The two Bidders will serve as examples. The father owed his striking success as an engineer primarily to his powers of mental calculation, which not only won him the friends who contributed to pay the cost of his education, but were of constant use to him in his profession. The son, a lawyer, tells us that he finds it an immense advantage to have in mind a number of formulas and constants for ready reference, and doubtless his readiness in using these formulas and constants in mental arithmetic was still more useful. Gauss and Safford are illustrations of the obvious possible usefulness of mental calculation to the mathematician.

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* American Journal of Psychology (abstract).

RUST AND MILDEW.*

ANNUAL DAMAGE IN THE UNITED STATES $500,000,000.

BY D. FINLAYSON.

THE innumerable species of microscopic fungi, which are in many instances so destructive to the life and vigor of many farm and garden crops, are diverse in structure and habit and of much importance. Though differing in their mode of life and the amount of damage they may do to particular crops, the species

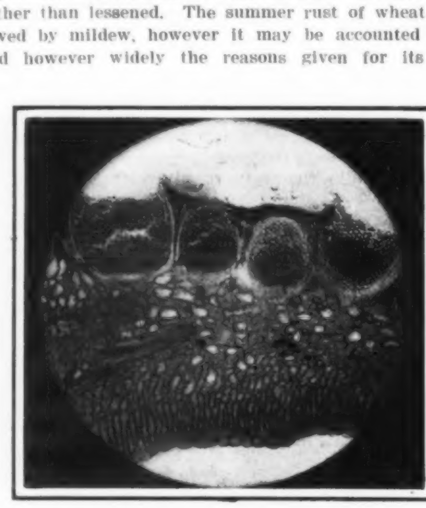
SHRIVELED GRAINS FROM RUSTED EAR.

agree in the absence of the beautiful green coloring so universal in the higher order of plants.

The physiological peculiarities whereby the growth becomes parasitic or saprophytic are entirely dependent upon the inability to manufacture and elaborate the foodstuffs required. In ordinary plants the green cells, particularly those of the leaves, may in a sense be likened to a manufactory or chemical laboratory where the various complex vital processes concerned in the elaboration of the foodstuff and th· nutrition of the plant are carried on. In the green cells, under the energizing action of sunlight, starch and other more complex compounds are formed from the elements of carbon-dioxide from the atmosphere in conjunction with water, bearing in solution mineral matter from the soil. Plants destitute of the green coloring matter (chlorophyl), such as the fungi, not being in a position to manufacture the food necessary, obtain a livelihood in one or other of two ways. One class of fungi live upon the decaying remains of plants and animals and are known as "saprophytes"; the other, the parasitic fungi, rob the living plant of prepared food materials, which would otherwise be used to maintain and increase its vigor, and in the ultimate production and development of healthy well-formed seeds. The cultivation of plants and seeds for the sustenance of the human race is recorded in the earliest writings of antiquity, and at the same time it is noted that the failure of crops of wheat from the attacks of rust and mildew was a source of anxiety and loss to the farming community at a very early period. Aristotle (350 B. C.) and other philosophers of

GOOD GRAINS. MAGNIFIED SAME AS THOSE SHRIVELED

ancient Greece and Rome in their observation of the wheat fields of their day speculated as to the cause of the failing of the crops, and endeavored to elucidate the apparent mystery surrounding it. At a much later date, toward the end of the eighteenth century, the opinion held by practical men concerning plant diseases in general is well summed up in an agricultural paper of the period: "Premiums offered for preventing evils which originate from intemperate seasons and destroying blights, may excite invention, artifice, cunning, imposture, and deception, but can never extend the boundary or expand the circle of human knowledge or human power. He, and He only, who can repel the malignant blasts of the East fraught with myriads of consuming insects, originating from what or where none but Omniscience knows, and substitute the soft, healing, balmy zephyrs of the West, can reward the industrious husbandman with plenty and happiness." Even in our own day of progressive enlightenment in everything pertaining to the science and practice of farming, we, no doubt, could find some who would concur in the above expressed submissive yielding to the "Powers that be." A striking instance came under the notice of the writer which shows that it is not unusual for those whose crops are sadly diminished by one or other of the common fungoid pests to ascribe the same to atmospheric influences or to some mysterious dispensation of Providence over which there is no control. In the case referred to, the farmer wisely—or, rather, unwisely—shook his head, and attributed the mildewed condition of his wheat fields or crop to some such occult influence as indicated, aided by weather conditions. When the life history of the fungus causing the mildew was fully explained, the credulity of the farmer was deepened rather than lessened. The summer rust of wheat followed by mildew, however it may be accounted for, and however widely the reasons given for its ap-



CLUSTER-CUP STAGE OF DISEASE ON BARBERRY PLANT (MAGNIFIED).

pearance may diverge from ascertained facts, is, unfortunately, too well known to all wheat-growers. The farmer, in some season or other, in looking over his fields during early summer cannot help noting that the fresh green appearance of the wheat crop is changing in color from day to day, becoming gradually quite yellow. On examining closely one of the withered leaves the observant cultivator can readily detect orange yellow spots or lines, and with the aid of a low-power lens can also see that the epidermal tissue of the leaf has been ruptured by the emission of countless numbers of orange yellow seeds or spores. The spots and lines upon the leaves multiply rapidly, and when the leaves are shaken by the wind the spores are set free and fall upon other leaves, and thus the disease is spread. Wherever wheat is grown, in this country, in America, throughout Europe, India and Australia, this destructive pest is known and dreaded. In appearance the disease is the same, wherever the crop attacked is grown—pale yellow during spring and summer, deepening later in the season to a dark brown or black, on the green leaves not only of the cereal crops, but of many surrounding wild grasses. In the early stages of rust the fungal spores or seeds are called "uredo" spores, from "uro," to burn, owing to the rusty or burnt appearance of the leaves. When these uredo spores are microscopically examined, it will be seen that they are oval in shape, with a granular rather than a smooth surface, their average size being about one thousandth of an inch in length. Ripe fresh uredo spores taken from a wheat leaf and kept for a few hours in a damp atmosphere soon germinate, the mycelia threads growing out from opposite sides of the spore. It has been proved times out of number that these uredo spores from the wheat upon fresh dry leaves remain in a resting condition until covered with a film of moisture either from dew or rain, after which they quickly germinate in great numbers. The germinal tube of the spore enters the stomata of the leaf, develops it

SPRAY OF BARBERRY, A HOST PLANT OF WHEAT RUST.

into a mass of new mycelia, which in ten days or so produce a fresh crop of uredo spores to further propagate the disease.

In examining a growing crop of rusted wheat the writer paid especial attention to the gradual transition from the rusted to the mildewed stage. Toward the end of July the plants under observation were badly rusted, the color of the spots and pustules on the leaves being a bright orange color; this darkened as the corn ripened, until ultimately the spots were dark brown, and the spores produced from the same mycelia which gave rise to the rust spore of the summer, turned out to be not the rust spores of the uredo stage, but the teleuto spores of wheat mildew. This proved the view held by some of the most famous biologists after repeated experiments that the disease so long known as wheat mildew (*Puccinea graminus*) was nothing more nor less than the autumnal form of the uredo or rust. The teleuto spores, so called, as they are formed late or last in the life history of the fungus, are the winter or resting spores of the disease. When these spores are placed under conditions favorable to germination they do not grow rapidly as do the uredo spores; in fact, it has been found practically impossible to make the teleuto spores grow without a period of rest, growth taking place only in the late winter or early spring. These last-mentioned spores are thick-walled two-celled bodies club-like or spindle shaped. When germination takes place in the spring a germ tube is protruded from each cell, which grows until its length is two or three

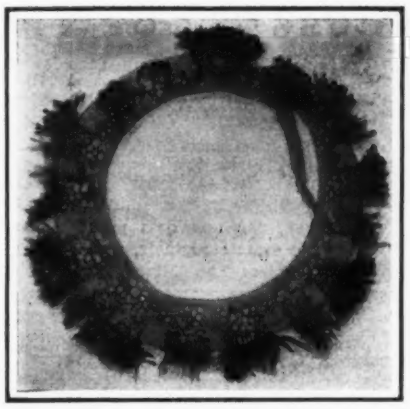
BARBERRY LEAF MAGNIFIED, SHOWING DISEASE ON UNDER SURFACE.

times the length of the original spore; partitions are then formed across the tube, dividing it into three or four segments, each segment becomes branched and produces at its apex small spore-like bodies known as sporidæ. These sporidæ in turn carry on the disease another stage. In the life history of the disease, which has manifested itself so differently, both as

* Country Life (London).

rust and mildew on the same plant, we have reached a stage which was for long beset with difficulty and disappointment. Many experiments were made to infect plants direct by means of teleuto spores or by sporidæ, either through the root, leaf or other surface, but without success. This was the condition of affairs when the late Prof. de Bary took the matter up, and after numerous painstaking observations established the connection between the cluster-cup or æcidium disease on the leaf of the barberry and mildew, the former (the cluster-cup disease) being simply an earlier form of mildew, living its life on another host plant and preceding the rust disease of wheat. De Bary discovered that practically at will he could produce the barberry disease by sowing the teleuto spores of wheat in the spring on a barberry leaf, and further, by sowing æcidio spores of the barberry on the young leaves of the wheat the presence of rust, and ultimately mildew, was a foregone conclusion. Though the above briefly describes the life cycle of rust and mildew, it would be as well to mention what Mr. Massee of Kew, one of the foremost mycologists of the day, says in his admirable book on fungi: "It is important to remember that the continuance of the species does not require that it (the complete life cycle) should be repeated every season. The uredo or summer spore condition alone, is sufficient to perpetuate the disease from year to year, growing during the winter on the leaves of wild grasses in sheltered situations, passing from thence to young wheat." The injury done to wheat by rust and mildew is well shown in the illustrations accompanying this article—the stunted character of the ears affected by rust in comparison with those which are healthy and vigorous; in another photograph the evil is further shown by the shriveled character of the grains. Surely these are direct evidence, if any is needed, that the fungus of rust and mildew, in preying upon the host plant, has appropriated to its own use the food prepared for the wheat. In this country, rust in its early stages rarely damages the wheat crop to any considerable extent. The vigorous assimilation of food by the wheat plant at the time of attack, aided by bright sunshine, enables the wheat to withstand the ravages of its foe and, perhaps with the exception of an occasional stunted ear, the wheat may be said to suffer practically little, if any, permanent injury. On the other hand, during a period of prolonged damp, muggy weather, weather specially favorable to the germination of repeated crops of uredo spores, which in turn ultimately produce mildew, occurring at a period in the life of the wheat plant when the active assimilation of food has partially, if not entirely, ceased. In this condition, when the elaborated food is being transported to the flower and fruit, the cells of the leaf are crowded with the mycelia of countless crops of the original rust which take possession of the flow of food stuffs and utilize it to its own advantage. Strong, healthy, vital seed, combined with improved methods of cultivation, the eradication of weeds from growing crops, and from the headlands and hedges, have doubtless done much to protect the farmer of this country from this pest, though it may be said that much yet remains to be done. Though there are no direct remedies for rust, clean cultivation, the burning of infected straw, which carries the resting spores of the disease over the winter, may aid considerably in the mitigation of the evil.

It is a hopeful portent for the future that some headway has been made in the production of a good all-round wheat, one that it is hoped will prove immune from rust, combined with the good qualities of high yield of grain and strength of flour, a union of qualities so much desired alike by the farmer and miller. The difficulty that has to be met and surmounted is the blending together in one ear or grain, rust resistance from one type, strength from another, yield and, perhaps, early maturity from yet another, and when the plant-breeder has realized his desires after years of research and experimenting, in all probability the new type he has evolved will be suitable only for growth and ability to maintain its character under similar conditions to that in which it was originated. Rust-resistant wheat grown in Australia became badly rusted when grown in America, and *vice versa*. It has been stated by more than one authority that the injury done by rust to cereal crops exceeds $500,000,000 per annum. The Department of Agriculture of the United States Government has put on record: "The damage to wheat and oats from rust in this country probably exceeds that caused by any other fungus or insect pest, and, in some localities, is greater than that caused by all other enemies combined."



MAGNIFIED SECTION OF WHEAT STEM. SHOWING RUST.

GOOD AND RUSTED EARS OF WHEAT.

RUST ON LEAF (WITH EAR).

RUST ON LEAVES (WITH EARS).

TURKISH MINERAL SPRINGS.

CONSUL ERNEST L. HARRIS furnishes the following information concerning the mineral waters and hot springs of the vilayet of Smyrna:

Among the bathing places in vogue are the springs at Tchesme, which are visited more than any others. From all parts of the Turkish Empire invalids come in large numbers to take the waters. The waters are sulphurous and saline, with a temperature of 135 deg. F., and are highly recommended for rheumatism and skin diseases.

Within seven miles of Smyrna are the hot springs of Lidja, which were known to the ancients under the name of the Baths of Agamemnon. They are useful against rheumatism. Between the springs of Tchesme and Lidja is a spring of saline waters, very similar to those of Carlsbad, much used as a curative for liver complaints.

The district of Pergamus boasts of several hot springs, the best known of which is at the village of Kinik. There are also hot springs in the district of Kouch-Adassi, which are popular locally. Three miles southeast of the ruins of Sardes, the hot springs still exist which were so renowned in ancient times. They are now little frequented, owing to their isolated location on the mountains.

At Alacheir, the ancient Philadelphia, a native company is bottling up the water of the Sarikiz spring, which is similar to Apollinaris, and which is now being exported in ever-increasing quantities. So much is this water now used in Smyrna and other cities in Turkey, that European bottled water has been practically shut out from the market.

Several hot springs are located near the city of Aidin, some of which have the reputation of healing wounds. All the waters of the Lycus valley are mineral, and most of them are thermal. Those of Hierapolis are still visited by the native population in great numbers. This Hierapolis spring goes up to 190 deg. F. All the mineral waters of this valley have incrustating properties.

According to a recent circular issued by the competent authorities, the exploitation of mineral springs in this vilayet, of whatever kind, will be granted, after analyses have been made, to the parties offering the highest royalty to the State.

HYDROGEN.

IN transmitting the following report, Consul Thomas H. Norton, of Chemnitz, says that much interest is felt in aeronautic and in certain mechanical circles in the perfection by a German professor of a method for the economical preparation of hydrogen gas on a large scale:

The materials employed in the new process of manufacturing hydrogen gas are water, coke, and calcium carbide. The first step is the production of "water gas," the well-known gaseous mixture obtained when a current of steam is passed through a thick layer of red-hot carbon. For some years past this cheap gas has been employed as a fuel and also for illuminating purposes, either when saturated with volatile hydrocarbons or in connection with incandescent mantles. Its own flame when burning in the air is almost destitute of luminous properties. Water gas consists of a mixture of hydrogen and carbon monoxide gases, with small amounts of nitrogen, etc. Theoretically the two gases should be present in equal volumes, but in practice the amount of free hydrogen is far behind the theory.

The professor has solved the problem of the elimination of the carbon monoxide from the mixture by bringing into play a very simple and elegant reaction. The gaseous mixture is conducted over glowing calcium carbide in the form of powder. As a result the carbon monoxide is completely decomposed in contact with the calcium carbide. Lime (calcium oxide) is formed, and carbon in the form of crystalline graphite is separated. This by-product of artificial graphite is itself capable of utilization for most of the purposes where the natural mineral substance is employed. The minor impurities of the original mixtures are likewise removed in the reaction, and as a result, hydrogen containing but 1 per cent of other gases is isolated.

COST OF PRODUCTION.

The process is one of extreme simplicity and cheapness, and allows of the easy and rapid production of large quantities of nearly pure hydrogen. An installation capable of evolving daily a volume of 70,000 cubic feet of hydrogen occupies a very small space. Hitherto those requiring the gas for balloons or the like have been forced to use the expensive process of preparation based upon the action of acids (hydrochloric or sulphuric) upon metals, usually upon iron. The transportation of acids to remote points is also attended with much inconvenience and difficulty.

In its notable lessening of the cost of hydrogen, the new process has accomplished for this gas what another scientist a few years ago did for oxygen when he introduced the method of the fractional distillation of liquid air, and thus secured an "air," consist-

ing of oxygen with but a slight admixture of nitrogen.

Cheap hydrogen is of great value at the present stage in the development of aeronautics, where, in many cases, it is of prime importance to have a much lighter gas than illuminating gas; for example, in polar exploration. This increased availability of hydrogen for technical purposes will likewise be of distinct value in extending its use for autogenetic welding.

BREAD.*

A SCIENTIFIC DISCUSSION OF THE STAFF OF LIFE.

BY A. E. HUMPHRIES.

Concluded from Supplement No. 1693, page 371.

WHAT constitutes good bread? The first essential is a pleasant flavor. It has occasionally a definitely bad flavor. That may arise from the flour used, or from faults in the bakehouse. Flour is peculiarly susceptible to taint. Railway cars which on some previous journey have carried tar or a tarry product have tainted flour through and through; the juxtaposition of paraffin, or even oranges, has caused similar damage. An exceedingly small proportion of musty or mow-burnt corns is fatal to good flavor. An actively bad flavor can also arise from bad or faulty fermentations. Mr. Kirkland, the teacher of bread-making at the Borough Polytechnic, has described the characteristic flavors of bread as a battle of flavors distinguishing that from a battle of germs in fermentation.

The baker seeks to set up an alcoholic fermentation, but the lactic ferment lives on the same sort of food; and though under ordinary conditions of baking the alcoholic fermentation has the better chance of thriving, lactic fermentation is almost invariably present to some extent. There may be also a fermentation whereby the alcohol produced in a healthy fermentation may be converted into acetic acid. Other ferments may be present, and if the baker allows, through miscalculations as to the necessary times and temperatures or through other errors, the proper and pleasant effects of alcoholic fermentation to be overcome unduly by the other fermentations present, his bread suffers, and he gets either a tasteless, or a sour, or evil-smelling bread according to the magnitude of his error. Flours from some wheats yield bread which is tasteless, even though the bakehouse treatment given them be correct. Such lack of flavor is usually correlated with a low natural moisture—in other words, such wheats are usually grown in a dry, hot climate; and though it is true that wheats subjected to great heat where the summer rainfall is high or substantial, such as those grown in Hungary and Manitoba, possess a very pleasant flavor, there are exceptions to the rule as to lack of flavor, and one is inclined to look behind the climatic influence for the cause of the characteristic. As a help to healthy fermentation, bakers use to some extent "malt extract." The proportion used is so small that the direct effect on flavor must be *nil;* yet the actual effect is in some cases substantial. An infinitesimal proportion of diastase has a potent effect on flavor, and I suggest, but do not as yet assert, that the natural flavor of wheaten flour depends to a large extent on its diastatic capacity. If sugar be added to the dough the effect on flavor is practically *nil.*

Closely associated with flavor in bread is its physical behavior in the mouth. If it there becomes doughy, its true flavor is obscured; and that is one reason why, if the true flavor of the bread is to be ascertained, it should be eaten one day old, and not soon after it comes out of the oven.

This by an easy transition brings forward one point as to digestibility. Saliva does important work, partly mechanical and partly chemical, in the digestion of food. If bread forms a doughy mass in the mouth, the saliva cannot be thoroughly mixed with it, and an initial serious hindrance is placed in the way of effective digestion. Flavor is a matter largely of personal likes and dislikes. Some people like stodgy bread, which keeps moist or even damp a long time. A good deal of the so-called old-fashioned farmhouse bread is of this description, the result of using weak flours, or of imperfect aeration, or of both causes combined. It is very much open to doubt whether a person used to high-class modern breads would care to eat this stodgy bread for any length of time, though as a change of diet it may at first be very agreeable; but, however that may be, it cannot be claimed that it is easily digested. For thorough digestion, a well-aerated loaf is essential, and that implies the use of a "strong" flour. There exists a popular fallacy that the use of a strong flour means dry-eating bread, and there is a substratum of truth in the idea: for strong flours will stand a long and severe fermentation. If poor-flavored bread results, the process of bread-making should be blamed, and not the strong flour. On the contrary, a strong flour, with its concomitant high percentage of natural sugar and its ability to stand a complete but rapid fermentation, can and does produce bread of superb flavor, free from stodginess, well aerated, and thoroughly digestible. The Minnesota experiments already referred to have shown, among other things, that the bread made from a strong flour can be digested quite as thoroughly as bread made from weak flours; so that the consumer is able to secure the full advantage of an increased proportion of nitrogen in his daily bread by the use of strong wheats, for great strength is generally an index of high nitrogen content.

There is no necessity to dwell at any length on the causes of whiteness in bread. The baker by scrupulous cleanliness and careful, intelligent attention paid to his bakehouse practice has had an important share in the great and palpable improvement in the appearance of modern bread, but the principal cause of the improvement in this particular lies in the wheats used and in their milling. A white flour which is weak will not make bread of the best appearance. Whiteness in bread is largely a question of optics. A stodgy bread will not appear to be as white or nice as one which is properly vesiculated. A loaf made from a weak white flour will not appear to be as white as one made from a blend of the weak white flour and a strong, even though the latter may as flour be darker than the former. The average blend of flour used to-day is much stronger than that in use fifty years ago, and the improved appearance of bread is in large measure due to that fact. But by far the most important factor in the improvement of color in bread is the modern mill.

Improved wheat cleaning, wheat conditioning whereby the wheat is put into the best condition for the separation of husk from kernel, diminution in the amount and intensity of friction used in grinding, and improvements in the methods of separating the products of grinding, have in the aggregate wrought a revolution in the methods of milling, so that the flour of to-day is an article very superior to old-fashioned flour, partly because it is really free from dirt, partly because it contains a far smaller proportion of powdered husk than the flours of olden times. We have already seen that powdered husk diminishes the dietetic value of flour.

It may be desirable to state briefly the most important principles of bread-making. The ingredients of bread ordinarily used are flour, water, salt, and yeast. A large proportion of the bread consumed in Great Britain is made from them, and nothing else. The substitution of milk for the whole or for a portion of the water is sometimes made, but that is not usual in England.

It may at a later stage be necessary to attach more scientific importance to the use of salt in bread-making, but for present purposes that may be regarded as a condiment. Bakers not infrequently use some form of yeast food, for the good and sufficient reason that there is not readily available in many flours enough food for the yeast. Sometimes scalded flour is used for that purpose, sometimes potato flour, or boiled potatoes themselves. The scalding or boiling gelatinizes the starch, and though the direct action of yeast on gelatinized starch is very small, a mixture of flour, yeast, and gelatinized starch by the complicated effects set up, does in effect provide the yeast with a more effective food than flour itself.

The use of potatoes has, however, greatly diminished, partly because modern yeasts are so much stronger than old ones, and can more readily obtain their food from wheaten flour; partly because high-class bread is darkened by them; partly because they contain so much natural moisture that their use is not profitable; partly because much more effective and reliable yeast foods have been invented or adopted. Where some form of "yeast food" is wanted, most bakers nowadays use either sugar itself or malt extract. I need not now pause to inquire whether yeast can get its food directly from cane-sugar or whether the hydrolyzing constituent of yeast has first of all to change cane-sugar into some other form of sugar before yeast can utilize it; but in effect we have in sugar a food which yeast can assimilate, and in malt extract an article which by diastatic action can convert starch into a food for yeast. Only an exceedingly small quantity of either is required—less than 1 per cent of sugar and say 0.25 per cent of malt extract, taking the quantity of flour used as the basis of calculation. "Malt diastase," or "absolute diastase," can bring about the same result, and then the infinitesimal proportion of 0.02 per cent will bring about striking differences in the size, appearance, and flavor of loaves produced from some flours.

Nobody could, or at any rate would, as an article of ordinary diet, eat loaves of the usual shape made from a mixture of flour, salt, and water, and baked soon after the mixture is made. Such a "loaf" made of 2 pounds 2 ounces of dough and baked in a tin would measure say 61 cubic inches. The same ingredients properly fermented and baked in a tin would measure say 170 cubic inches. The difference is due to inflation by gas, mostly carbon dioxide. In the first case, the crust would be so hard that ordinary human teeth could not break it, yet the "crumb" would be practically dough itself, utterly repugnant to the taste, and highly indigestible. Unless such a dough be baked in very thin layers, which the heat could penetrate in baking, it is inedible, and in that form it is no longer bread as modern people understand the term. Aeration is essential. This may be brought about in several ways.

If a mixture of flour, salt, and water be put into a sterilized receptacle, covered up and left under favorable conditions for say thirty hours, one or more forms of fermentation are set up spontaneously. I need not attempt to say what chemical changes have taken place, or what gases have been generated, but the loaves so produced, bad though they may be, are very much better than those produced from the same mixture baked soon after the mixing is done. Such loaves weighing 2 pounds measure say 73 cubic inches, have a peculiarly sour, but not unpleasant, taste, and smell like cake. A man traveling in the bush would find this form of fermentation very much better than none at all.

There have been many attempts to obtain a satisfactory aeration of loaves without the use of yeast. Yeast itself is not inexpensive, and there is this further point about its use which adds to the expense. When "sown" in a favorable "soil" the plant grows amazingly, and yields as a result of its growth the gas carbon dioxide, the best of known bread aerators, and alcohol. But "out of nothing nothing comes," and the yeast lives on the "soil" or, to be precise, on those elements of the "soil" which it can assimilate. This means that the yeast absorbs and converts into those products, the greater part of which is lost to the baker, a substantial proportion of the flour, say 2 per cent—a large amount in the course of a year. But none of the substitutes for yeast are satisfactory, though they do not use up for bread-making purposes any of the flour itself. One gas-producing combination used was hydrochloric acid and bicarbonate of soda, yielding carbon dioxide, the good aerator, and salt, the necessary condiment. But the process is bad for two principal reasons: one, that commercial hydrochloric acid often contains arsenic; the other, that the gas generated is evolved very rapidly—so rapidly that the difficulty of retaining it in the dough, always a great one, is very much intensified. The second of these two objections can be raised against any form of baking powder aeration. To minimize it, small quantities of flour and water can be used; but that provides its own condemnation in the estimation of the baker, and in any case a far larger proportion of the gas generated is evolved very rapidly—so rapidly that in the slow and comparatively regular way of yeast fermentation.

The most successful of all the alternative methods of aeration is the Dauglish process, used for the production of aerated bread. Everybody is acquainted with aerated water as a beverage, and the gas which bubbles out of it when an outlet is provided. The essential idea of the Dauglish process, which has been modified in details since its introduction, is the mechanical kneading of the proper proportions of flour, salt, and water under a pressure of from 7 to 14 atmospheres of carbon dioxide. When the dough

* Ex-President of the Incorporated National Association of British and Irish Millers, in Science Progress.

so prepared emerges from the kneading machine, it expands because of the gas within it. The whole process is a rapid one, and the difficulty of retaining the gas within the dough is minimized as compared with "baking powder" methods. But "aerated bread," good though it is, lacks the characteristic and pleasant flavor of first-class yeast-fermented bread. The chemistry of flour and bread is particularly abstruse, and as a layman I am content to say that the complicated actions and reactions resulting from yeast fermentation do cause, when the best of flours and the best methods are used, a particularly pleasant flavor, which aerated bread does not possess. If the alcohol produced has any direct effect, it must be evanescent, for if any at all be left in the bread as it leaves the oven, the proportion is so exceedingly small that it may be regarded as non-existent. Any carbon dioxide that may be left rapidly disappears by diffusion.

For practical purposes yeast holds the field. One important modern development of bread-making is the comparative ease with which high-class yeasts can now be obtained. It is not essential to obtain pure cultures, for the other micro-organisms which exist in commercial yeast can only develop very slightly in dough; but however that may be, modern yeast is a high-class article, produced generally under favorable conditions by specialists and distributed rapidly by our modern wonderful facilities for transport. There can be no doubt that these modern developments are wholly good. In days gone by, some of the fermentations were of the very highest class, but the results were often irregular and poor. A far higher percentage of regularly good results is now obtained. In old literature the term "leaven" is frequently met with. That consists of a portion of dough held over from a previous baking. The fresh fermentation is started by the mixing of the old dough with fresh flour and water, and after an interval the admixture of a little beer yeast and more flour and water. The first batch produced by this method in any day is relatively sour and dark. The advantages of starting an entirely fresh fermentation for each batch of bread are so great that the older method can be said to have been discontinued in England. Formerly bakers used to make their own yeasts from flour, malt, hops, potatoes, sugar, and water as the principal ingredients, but the comparative disuse of the term "barm" indicates that that way of making yeast by rule-of-thumb methods has given place to the modern scientific ones. Brewers' barm has also been discarded. Bakers say that since brewers began to use substitutes for malt and hops, their barm has become too unreliable for regular use. Whether that be strictly true or whether the modern specialized manufacture of yeast has provided an article relatively better need not be discussed. As a matter of fact, compressed distillers' yeast has almost entirely ousted the other forms of yeast. The effects of present importance may be summarized in the statements that the processes of bread-making have been very much shortened; that modern fermentations approximate more nearly to the desirable pure alcoholic fermentation than olden ones; that it is possible in a large proportion of cases to use flour, salt, water, and yeast only, dispensing thereby with the use of potatoes and other forms of non-farinaceous yeast foods, and that as a consequence bread is less likely to be sour or discolored by undesirable causes than it ever was.

One absolute essential for the production of good bread is the use of good flour. It must of course be pure and free from all dirt and contamination—"that goes without saying"—and modern flour complies with those requirements. It should also contain a sufficiency of food available for the yeast plant, and be able to retain when made into dough a large proportion of the gas into which some of its own constituents have been changed by the action of the yeast. The possession of those characteristics mainly constitutes "strength." The loaves produced from such flour are large, and therefore well aerated, probably shapely, and relatively digestible.

In the April number of The Journal of Agricultural Science there is a most valuable and interesting article by Prof. T. B. Wood, of Cambridge. He has shown from experiments on a considerable number of flours, each produced from a single sort of wheat, that "the size of the loaf depends in the first instance on the amount of sugar contained in the flour together with that formed in the dough by diastatic action." In his summary he also says:

"It is suggested therefore that the difference between strong and weak flours is connected rather with the physical properties of their gluten than with the chemical composition. Since it is well known that the physical properties of proteids are profoundly affected by small quantities of acids, alkalies, and salts, the amounts of these substances in strong and weak flours were determined. In the few cases examined it was found that strength was associated with a high ratio of proteids to salts, and weakness with a low ratio. It is suggested that the variation of this ratio may be the explanation of the different physical behavior of the gluten of strong and weak flours, and that this is the factor which determines that component of strength which governs the shape of the loaf, and its power of retaining gas. This point is receiving further investigation."

This, the latest of all suggestions as to the cause of strength in wheaten flour, seems by far the most feasible put forward. Comparatively recent work has shown that the possession of a good or even of a high nitrogen content is not of itself a certain indication of strength, and the quality of gluten measured by the ratio of gliadin to glutenin is no indication whatever of strength. As a consequence chemists have seemed to be unable to account correctly in terms of their own science for that characteristic of strength which adds so much to the commercial and dietetic value of certain wheats; and if Prof. Wood can show a definite connection between the percentage of fermentable matter in wheat, the percentage of glutenous matter, and the effect on its gas-retaining capacity of its varying percentages of acids, alkalies, and salts, he will have done that which has baffled many chemists the whole world over for many years. By the time this article is published the subject of strength in wheat, more particularly its bearing on the culture of strong wheats in England, will have been discussed at the Leicester meeting of the British Association. Let us hope that by then this hopeful suggestion may have been transformed into definite assertion.

HOW THE EARTH IS WARMED.

HOW CONDUCTION, CONVECTION, AND RADIATION ALL TAKE PART.

BY PROF. POYNTING.

The earth is warmed chiefly from three sources:

(1) The sun, supplying heat day by day.

(2) Coal, the sunshine of past ages stored up.

(3) The inside of the earth, which is probably very hot.

We can find the rate at which we get heat from the sun by measuring the rise in temperature per second of a body exposed to full sunshine.

The heat we get out of coal can be calculated from the quantity raised—about 2,000,000 tons per day over the whole earth.

The heat from the inside of the earth may be roughly estimated by finding how the temperature rises as we descend deeper and deeper into mines.

The three sources probably give us heat in some such proportion as 250,000 to 1 to 50.

The sun thus gives nearly all our warmth, and we shall consider only how this comes to us.

There are three ways in which heat is given by one body to another.

(1) Conduction, when the heat travels from a hotter part of one body to a cooler part, or passes from a hotter body to a colder one in contact with it. If we think of the temperature as sloping down from a hot body to a cold one, heat is always conducted down hill. It never rises up the hill from a cold to a hot body. The heat we get from the inside of the earth comes to us by conduction. The water in a boiler is warmed by conduction. The space between us and the sun is very much colder than either the sun or the earth, so that heat would have to come up hill from this space to be conducted from the sun to the earth. This does not happen, so that no heat is conducted to us from the sun.

(2) Convection. This occurs when hot matter is conveyed from a source of heat to a colder body to which it gives heat by conduction when it comes against it. This mode of heat carriage is used in hot water and steam pipe warming. A very small quantity of heat may perhaps reach us from the sun in this way, but it is at the most exceedingly small.

(3) Radiation. This is the way in which heat comes from the sun. It is heat in the sun. It is converted as it issues from the sun into a traveling form of energy, not heat, and it is converted into heat again, when it falls on a surface which absorbs it, and is warmed by it. It does not appear to need ordinary matter to carry it. It passes quite freely through the almost empty space between the sun and the earth. It resembles light in traveling in straight lines, in being reflected by mirrors, and in being refracted by lenses, and it is present always with light.

Everything we know of light shows that light consists of waves. If we pass a beam of white light through a prism it is split up into colors ranging from red through yellow and green to blue and violet—the spectrum. The red waves are the longest, about 1/35,000 inch long, and the waves shorten as we go up the spectrum to the violet, which are about 1/60,000 inch long. But these are only the waves which affect our eyes. There are longer waves than the red, which we cannot see, but which the thermometer feels, and there are shorter waves than the violet, which the photographic plate sees.

Very hot bodies pour out waves ranging from lengths much greater than red to lengths much less than violet. These waves, of whatever length, constitute radiation or radiant energy. Light is only a special range of radiation to which our eyes are sensitive. The energy is heat energy before it leaves the sun; it travels through space in the wave form, and when it meets an absorbing surface here it generally turns into heat again; but it may give the sensation of light if it falls on our eyes, a photographic picture if it falls on a sensitive plate, or vegetable growth if it falls on leaves.

All bodies are always pouring out radiation. At ordinary temperatures perhaps the wave lengths are chiefly about 1/2,000 inch long, and the shorter waves are exceedingly weak, far too weak for our eyes to see. As the temperature rises the shorter waves are stronger. At 450 deg. C. a body sends out red waves strong enough to let us see it as red. At 900 deg. C. it sends out all the visible rays, and we see the body white hot. The carbon of the electric arc is at about 3,500 deg. C. and the sun's surface at about 6,000 deg. C.

We do not notice that bodies at ordinary temperatures are pouring out these waves, for they are also receiving waves from all the bodies round them. They receive as much as they spend, and so the heat in them is kept constant and at the same level of temperature.

Tyndall's "Heat: a Mode of Motion," contains an account of radiant energy.

Syllabus of a lecture delivered at the University of Birmingham.

ITALIAN FLOUR WAFERS.

Consul James E. Dunning, of Milan, forwards the following report of the consulate, on the flour-wafer trade in Italy:

The flour wafer, composed of flour and water cooked, is used in Italy much more than in the United States for medical purposes. It takes the place of the capsule to a certain extent. A comparatively large quantity is also used in the manufacture of nougat.

Flour wafers used medically sell on the Italian market for from 15 to 18 cents per pound. Lower rates would probably be given for large quantities. A list of manufacturers in Italy accompanies this report.

The manufacturing process of the various kinds of flour wafers in Italy is very simple. The flour and water are mixed and laid on either of two iron plates, and the wafers are pressed to the required thicknesses by moving two iron handles. After this the pressed wafers are cut into any size required by a machine. These mechanisms are manufactured to order by all Italian iron works. There is no special machine as yet introduced or evidently needed in this industry in Italy.

The flour wafer used for nougat is simply rolled instead of pressed. The nougat manufacturers make their own flour wafer, which contains a small percentage of sugar. The flour wafer used by the church in Italy is practically all made in the convents, which are fully equipped for its manufacture.

Belt Cement.—I. Soak 100 parts by weight of glue with 150 of cold water and melt in a water bath; when completely dissolved, mix with 3 parts potassium bichromate and 3 parts of glycerine. The cement should be applied hot, and the belts roughened by means of a rasp for a length of at least 8 or 9 inches. After using the cement press the belt firmly in a clamp between two boards and leave to dry for 24 hours. II. Treat 100 parts by weight of glue in the manner described, and when dissolved add 15 parts of tannin and 3 of glycerine.—Neueste Erfindungen und Erfahrungen.

DR. SCHLICK'S GYROSCOPIC APPARATUS FOR PREVENTING SHIPS FROM ROLLING.*

BY M. WURL.

A VESSEL in a seaway is subject to periodical movements which may be divided into three classes, viz.:

1. Heaving, i. e., vertical up and down movemen of the ship bodily.
2. Pitching, i. e., swinging about a transverse axis so that the ends of the ship move up and down.
3. Rolling, i. e., swinging about a longitudinal axis so that the sides of the ship move up and down.

All periodical movements are accompanied by forces of acceleration and retardation, whose effect upon the human organism is more or less unpleasant, and all the movements mentioned are therefore apt to cause sea-sickness more or less, in accordance with their character, their magnitude and their frequency.

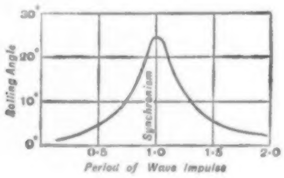


FIG. 1.

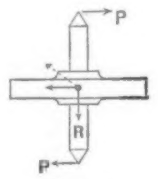


FIG. 2.

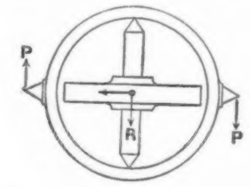


FIG. 3.

Heaving motion is unavoidable with ships designed to float on the surface of the water and therewith on the surface of waves. Submarines are naturally less liable to heaving, as the wave motion decreases with the distance from the surface of the water, but compared with such a mode of traveling, probably heaving will appear as the smaller evil. The range of motion, according to the height of sea waves, is not infrequently 20 feet, and sometimes may exceed even 30 feet, but fortunately the frequency or the period in such cases is not high, and with shorter periods the amplitudes are proportionately smaller, so that in either case the accelerating forces do not exceed certain limits. Furthermore, the pure heaving motion, with the decks keeping horizontal, seems to have comparatively little effect upon the human frame, and observations show that considerable amplitudes are satisfactorily borne by most people. This is, perhaps, the reason why heaving is so rarely mentioned as a cause of sea-sickness.

Pitching is considerably more dreaded, and the movement is undoubtedly most unpleasant at the ends of a vessel, considering that the period of pitching is generally very short, and one may be pitched over 30 feet up or down within two to three seconds. But pitching has the relieving feature that its effect can be evaded, almost entirely, by staying amidships, where the vertical movement due to pitching is naturally *nil;* the remaining angular movement does not often exceed 4 degrees to each side, and is, therefore, immaterial in comparison with rolling, where not infrequently angles of five times that amount are recorded.

In rolling, two movements should be distinguished, viz., the vertical movement at the sides of the vessel, and the much more disagreeable angular movement which equally affects all parts of the ship, and therefore cannot be evaded. Small angles up to about 5 degrees to each side are of little consequence, but the effect of angles over 10 degrees or even 20 degrees, is not so easily forgotten; and people who have experienced real rolling of this description, who have felt the discomfort of moving about on board a ship when the level of the decks is changing incessantly from side to side, who have seen dishes, plates, vegetables, etc., sliding and rolling about the dining-table, and especially those people who have avoided altogether the sight of the dining-tables on such occasions, will not long for a similar experience. The general wish, under such conditions, is that the rolling should stop, and probably there is sometimes an indistinct hope that some mysterious power could appear and hold the ship steady. This power has now appeared with Dr. Schlick's invention of his gyroscope for preventing ships from rolling.

Prevention is to be distinguished from reduction of rolling. Various appliances have been devised for the latter purpose, so for instance the bilge keels, now almost generally applied, form a simple expedient for reducing rolling to some extent. But as their effect depends upon the water resistance set up against the rolling motion itself, considerable angles of roll must necessarily remain under all conditions, in order to produce an effect, and therefore nothing but a moderate reduction of rolling can be expected from bilge keels in practice. The same applies to rolling tanks and other appliances whose action depends upon the existence of large rolling angles.

To prevent rolling it has to be stopped at the root so to speak; and to understand fully how this is accomplished by Dr. Schlick's gyroscope we must first understand how rolling arises. Closely connected with this problem is the well-known fact that some vessels show a great tendency to rolling while others hardly ever roll at all.

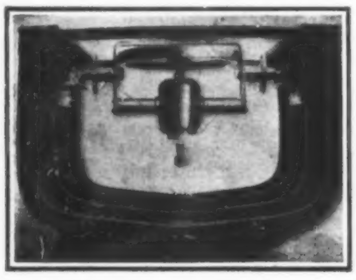
A vessel in still water when forcibly heeled over and then suddenly released behaves like a pendulum, viz., carries out a number of oscillations about its upright position, which decrease gradually in their amplitude but succeed each other in equal intervals of time. This constant time interval, called the natural period of the vessel, depends to a great extent upon the metacentric height of the vessel, and is therefore a factor of the design, so that the naval architect is enabled to give the ship a long or a short period as may be required. The period is of great importance in a seaway in connection with the periodical movements forced upon the ship by the impulse of the waves.

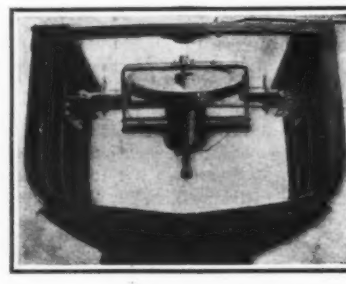
The waves passing underneath a vessel tend to incline it so as to bring the decks in parallel with the effective wave slope. If the waves are not met in quick succession, the movement actually taking place will be very small, from want of time. Further, if the waves are met very slowly, the ship will have time to follow the wave slope closely, and the maximum angle of roll will be equal to the maximum effective wave slope, which is generally moderate. Serious rolling is, however, almost certain, even in a comparatively light sea, when the waves are met at such regular intervals as correspond with the natural period of the vessel, or in other words, when synchronism exists between the period of the wave impulse and the natural period of the vessel. In such cases the rolling angle gradually becomes larger with each wave, the rolling is accumulative, and with perfect synchronism the angle would become infinite, i. e., every ship would turn turtle if it did not encounter sufficient water and air resistance, which absorbed the energy added to the swinging vessel by every fresh wave impulse. Naval architects are paying due attention to this problem, and the factor of safety in modern ships is so great that cases of overturning through excessive rolling are almost unknown.

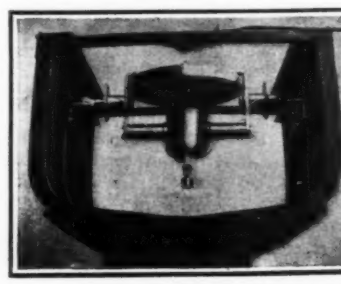
Nevertheless, the rolling angle accumulated at or near the period of synchronism is usually many times larger than the maximum effective wave slope producing it. To illustrate the relative tendency of a vessel toward rolling under the conditions mentioned, Fig. 1 has been prepared; it represents the maximum rolling angles which could be accumulated by waves, all of the same height, but meeting the vessel at different time intervals or periods. The curve applies to an actual ship ("Seebar"), and has been derived from various observations; further investigations show that other vessels would yield curves more or less similar in character. Fig. 1 indicates that by far the greatest rolling angles occur at or near the period of synchronism, at higher or lower periods the angles become rapidly smaller. It is therefore obvious that rolling can be avoided, to a great extent, by avoiding synchronism.

The possibility of avoiding synchronous rolling was recognized many years ago, when observations had shown that the actual periods of wave impulse, generally met with at sea, are comparatively short and can be greatly exceeded by the ship's period, if the metacentric height is kept sufficiently small. But although this has been frequently pointed out by leading naval architects, there are still many ships afloat with too short a period, so that heavy rolling is frequent with them. Others are much less liable to roll, as mentioned above, and it is likely that further improvements can and will be made in this direction; yet, however long the period of a vessel may be, the chances of synchronism and therewith the chances of heavy rolling still exist, especially with a quarter sea.

To deal with such cases as these, i. e., to prevent rolling under any conditions of sea, but especially under the conditions of synchronism, is the object of Dr. Schlick's gyroscope. The apparatus consists principally of a heavy flywheel rotating at a considerable speed, and supported in such a way that any tendency of a wave to heel the vessel over sets up gyroscopic forces in the apparatus, which practically counterbalance, at every instant, the effect of the wave, and thus prevent the ship from rolling.


THE GYROSTAT IN VERTICAL POSITION.


THE GYROSTAT TILTED FORWARD.


THE GYROSTAT TILTED BACKWARD.

PRACTICAL TESTS OF THE SCHLICK GYROSTAT FOR SHIPS.

To avoid misunderstanding, it may be pointed out that these forces, set up in the apparatus, are active forces and must not be confounded with ordinary dead resistances, which would be offered by the ship, if it was kept absolutely rigid, as for instance on a rock. It must also be mentioned, that the steadying effect is not merely due to the presence of rotating masses, so for instance, steam turbines in a vessel or even Schlick's apparatus under certain conditions, as will be shown later, have not the slightest effect upon the rolling. To explain these and other phenomena, connected with the present problem, a brief investigation

* Journal of the Society of Arts.

regarding the origin of gyroscopic forces will be necessary.

Suppose a wheel or disk (Fig. 2) be rotating so that the mass element or particle at the front side of the circumference would move toward the left, as shown by the full-drawn arrow. The forces *P P*, tilting the axis of rotation, tend to bring the particle into a new direction of movement shown by the dotted arrow, and it is evident that the resistance offered by the

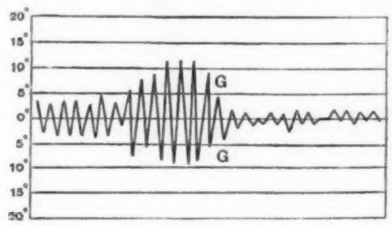


FIG. 5.

particle against this change will be downward as indicated. As the particle passes on, others will appear in its place, and the resistance, *R*, will consequently last as long as the tilting movement of the axis continues in the indicated direction, *P P*. A similar consideration shows that the same tilting movement causes particles passing through the opposite position at the back of the circumference, to offer resistance upward. Particles at both sides of the circumference do not change their direction of movement and, therefore, offer no resistance against the tilting of the axis. Partly one and partly the other of the three conditions mentioned applies to all the intermediate mass particles, at the circumference of the disk as well as anywhere inside. All the front particles exert gyroscopic forces downward, and all those in the back of the disk upward, their combined effect being a resisting movement or couple whose axis is at right angles to the axis of the tilting movement, *P P* (compare Fig. 2). A strict mathematical investigation shows that this couple increases in direct proportion with the angular velocity of tilting, with the speed of rotation, and with the inertia moment of the rotating mass.

All these facts can be corroborated by experiment and some by observation in practice. So for instance, on a paddle steamer the following phenomena can be observed:

1. If the course is suddenly changed, the vessel heels over.

2. If the vessel is heeled over, say, by a wave, the course is slightly altered.

These phenomena are largely due to the gyroscopic action of the paddle wheels, but, owing to the small rotary speed of these wheels, the effect is generally so slight that it is not easily noticed. To show these phenomena much more clearly, a model has been designed, in which the two paddle wheels are represented by solid disks revolved at a high speed by means of a small electric motor. The little vessel is so supported that it can heel over to either side and turn freely about a vertical axis. It is noticeable, with the wheels revolving, that a slight turning of the bows to starboard causes the vessel to heel over to port, and convertibly. Further, if the vessel is heeled over by a small weight added to one side, it starts to turn and alter its course; for instance, by heeling over to starboard the ship's bow is turned to starboard. It is rather curious that this should take place in practice, as the starboard paddle would be deeper immersed, when the vessel is over to starboard, and would, therefore, tend to turn the vessel in the opposite direction, i. e., to port. Yet the phenomenon was observed by Dr. Schlick some years ago and has induced him to a closer study of this problem and of gyroscopic problems generally; the result of these studies was the invention of the gyroscope which forms the subject of this paper.

A further example for demonstrating gyroscopic forces is the portable gyroscope, consisting of a flywheel mounted in a circular frame; when set spinning it can be moved about with its axis parallel, without offering any appreciable resistance; but gyroscopic forces can be distinctly felt with this apparatus when holding it in two hands and producing the necessary tilting movement; it can also be noticed that this strange resistance does not act in the direction of the movement, but in a plane at right angles to the intended tilting movement. This latter fact, which coincides with the preceding investigations, goes to show that a gyroscope like this, if fixed in a ship, could not resist any impulses of the waves, because the gyroscopic forces produced would always be at right angles to the forces of the waves, and could, therefore, have no steadying influence. The same argument applies to any other rotating mass on board a ship, as steam turbines, paddle wheels, etc.; and no steadying power can be expected from these, because their axis of rotation is fixed in the ship, and therefore practically immovable in certain directions.

That the effect is *nil* under these conditions, can easily be judged by the movement of this model pendulum, which has a gyroscope of the preceding type attached to it. The pendulum swings with a certain period when the flywheel is at rest, and the experiment shows that the movement is exactly the same after the flywheel has been set spinning. It is, therefore, evident that something more is required for creating those forces which are necessary for preventing ships from rolling.

Fig. 3 shows the flywheel placed in a frame, which is held in bearings at the right and left, so that it can swing about this horizontal axis. The forces, *P P*, acting now upon the frame, and tilting it in the direction indicated, create gyroscopic forces, *R*, as has been explained in connection with Fig. 2; viz., the forces, *R*, are directed downward in the front parts of the wheel, and upward in the back. The same rule applies, if we look at the wheel from the left-hand side, and assume that the frame be tilted by the forces, *R*. As the direction of the movement is in every way the same as in the previous case, the gyroscopic forces set up by the new tilting movement will again be downward in front of us, that is at the left side of Fig. 3, and upward at the opposite side, forces which are evidently both opposed to the original forces.

The arrangement shown in Fig. 3 is consequently able to oppose tilting or angular movements, as may be further demonstrated by our pendulum apparatus. It will be remembered that the swinging movement of this model pendulum was not in any way modified by the gyroscope attached to it. The reason for

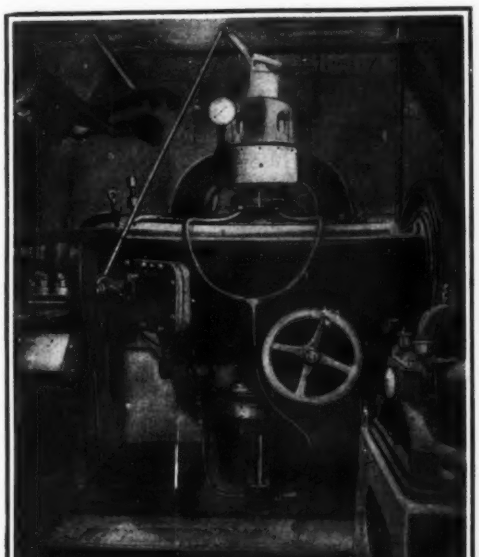


FIG. 4.—THE SCHLICK GYROSTAT IN THE "SEEBAR."

this was that the gyroscope frame had been prevented from swinging and consequently from acting upon the pendulum, as will be obvious from the explanations given. If now the frame is released and left free to swing, it will be noticed that the same pendulum is very much slower in its period; because it is practically held steady in its extreme positions for a short interval of time, until the gyroscope has finished its full swinging movement of about 180 degrees, and therewith exhausted its resisting power.

It will further be noticed that, although the pendulum is retarded each time, and its period is thereby lengthened, the amplitude does not decrease, and consequently, if such a gyroscope was applied to a ship and any appreciable roll did appear, the apparatus would not be able to extinguish it. And naturally so, because the apparatus has no means yet for absorbing any of the energy contained in the vibrating system. To remedy this, Dr. Schlick applies brakes to the swinging movement of the gyroscope frame, and as the small friction brake of this pendulum apparatus is brought into action, the movement of the pendulum is quickly extinguished. (Shown by experiment.)

There are consequently two outstanding features in Schlick's gyroscope, viz.: (1) The general arrangement of the apparatus; and (2) the brakes.

The general arrangement is shown diagrammatically in Fig. 3. The axis of the flywheel may have any position transversely to the ship, but provision must be made that it automatically returns to this position, in order to produce the best results. The axis of the

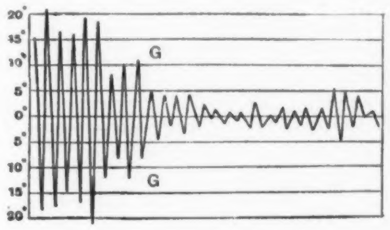


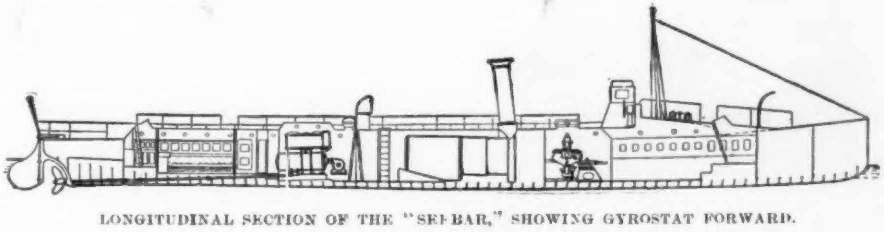
FIG. 6.

oscillating frame is also placed transversely in the ship, but at right angles to the above normal position of the flywheel axis, whose ends move in the fore and aft direction when the frame is swinging. These conditions are fulfilled in the two pendulum models here exhibited, whose vibrations may represent the rolling motion of a vessel. In one of the pendulums the axis of the flywheel is originally vertical; in the other one it is horizontal, and the experiment shows that both gyroscopes behave in a similar manner, and increase the period of the pendulum equally well. But preference is generally given to the arrangement where the forces of gravity can now be employed for returning the flywheel axis to its original position, which simplifies the design.

As mentioned above, the brakes form another important feature of Schlick's apparatus and cannot be dispensed with. The small models exhibited were the gyroscope fitted in the small vessel which is floating in the small tank and the other apparatus (Fig. 4) applied to one of the sections of a vessel, have both friction brakes, which are always in action, and therefore readily extinguish any angle of heel given to the models in question. For larger machines the brakes are more elaborate, they are either hydraulic or friction brakes, and generally so designed as to meet the varying conditions of sea automatically, and to safeguard the gyroscope apparatus against overloading.

This second model further shows that the gyroscope offers no resistance against rolling, if the frame is tilted so far, that the axis of the flywheel becomes horizontal. This is due to the obvious fact that in this position, viz., with the flywheel axis in the fore and aft direction, no resisting couples can be transmitted through the axis in the direction of rolling. The resistances are necessarily vertical to the flywheel axis and, therefore, only a component of these resistances is useful in preventing rolling; at 90 deg. deflection of the gyroscope frame the component becomes zero, as already explained. Should the frame swing further than 90 deg., the tendency of the apparatus would be again to prevent rolling, and even an overturning of the gyroscope as shown by this model, would not reverse its action. Practical considerations, however, lead to the adoption of a limit for the swinging motion, and stops are generally provided to arrest the frame, before an angle of 90 deg. to each side is reached; such stops are existing at angles of 45 deg. in the small tank model.

Another appliance generally fitted is a brake, or other suitable device, for holding the gyroscope frame in a fixed position, and thereby suspending the action of the apparatus, even with the wheel rotating, as previously explained. Both the models described here have such appliances, and the experiment shows that, with the apparatus thus put out of action, considerable rolling angles can be quickly accumulated by applying a comparatively small weight eccentrically in regular intervals, as would correspond with the action of synchronous waves. But when the apparatus is put into action by removing the clutch that holds the frame, and the same weights are applied in similar intervals as before, the vessel remains practically steady, the residuary angle of roll required for the working of the apparatus being hardly percep-



LONGITUDINAL SECTION OF THE "SEEBAR," SHOWING GYROSTAT FORWARD.

PRACTICAL TESTS OF THE SCHLICK GYROSTAT FOR SHIPS.

tible, and only the gyroscope is seen swinging to and fro. This is very similar to the working of larger gyroscopes on board a ship at sea, and careful investigations have shown that a properly designed apparatus is able to adjust its movements so quickly, that equilibrium with any external moment is generally established within the fraction of a second, and all the irregularities of the wave impulses are followed by the machine with an astounding accuracy. It is therefore perfectly certain that rolling can be practically prevented by a well-designed apparatus of sufficient size.

What size the apparatus ought to be for a certain size of vessel, under the conditions of sea met with in practice, has been early recognized by Dr. Schlick as the vital question of his invention. He also realized that only experiments on a large scale could bring this problem nearer to its solution. He therefore purchased a suitable vessel, a German torpedo boat, and fitted it out with a gyroscope of comparatively large size. The steamer is 117 feet long, 12 feet 6 inches broad, and displaces 65 tons on a draft of 3 feet 10 inches, the metacentric height is 1.3 feet, and the natural period of rolling about 2.1 seconds from side to side. The gyroscope wheel is driven by steam, turbine blades being fixed on its circumference. The frame of the gyroscope is represented by the steam-tight cast-iron casing, receiving and exhausting the steam through the trunnions on which the gyroscope oscillates. The diameter of the steel flywheel is about 39 inches, and its usual speed of rotation about 1,600 revolutions per minute. The hydraulic brake for controlling the oscillatory movement of the frame consists of a cylinder with a piston forcing the fluid through a valve, the opening of which can be regulated from the deck. The arrangement for putting the apparatus out of action consists of a friction band brake, also operated from deck, by which the gyroscope frame or casing can be held in a fixed position or released as may be required.

The experiments carried out with this apparatus by Dr. Schlick yielded most satisfactory results, and it was found that the vessel could be kept steady in a sea which produced rolling angles up to 20 deg. to each side with the apparatus out of action. Fuller details of these trials are given in a paper read by Sir William H. White before the Institution of Naval Architects in 1907.

The success of these experiments has induced Messrs. Swan, Hunter and Wigham Richardson, Ltd., of Wallsend and Walker on Tyne, to acquire from Dr. Schlick the patent rights for the British Isles, France, and America, including the experimental vessel "Seebär," which is now generally called "Seebar."

Further trials have been carried out with this vessel recently off the Tyne, in the open sea. Dr. Schlick's experiments were made in the lower Elbe, and his greatest cause of complaint and disappointment used to be that the surface of the water was generally not sufficiently rough for the intended rolling trials. Such disappointments were hardly ever met with in the experiments off the Tyne, and even in moderate weather the sea was rough enough to toss the "Seebar" about violently. But the drawback was that the waves were generally so irregular in length that the condition of synchronism could seldom be far enough approached for accumulating a large rolling angle without, and thus the apparatus could not be shown to its best advantage. Nevertheless, the steadying effect was marked under all conditions of sea met with, and could be felt distinctly by everybody on board; so that the visitors who witnessed some of these tests, viz., representatives of various steamship companies and others, were generally convinced within a few minutes that by turning a certain wheel on deck, and thereby putting the gyroscope into action, the rolling could be stopped almost immediately, and further rolling could be prevented until the same wheel was turned in the opposite direction and thereby the action of the gyroscope again suspended.

Some of the results obtained during the various trials are reproduced in Figs. 5 and 6, showing the consecutive rolling angles to port and starboard. The left-hand part of the diagrams represents the rolling observed without the gyroscope in action; at G the gyroscope frame was released and the apparatus began to act, with the results indicated in the diagrams. A small angle must necessarily remain to overcome the initial friction of the apparatus; this angle is as a rule negligible, as in Fig. 5, and we may say that rolling is practically prevented as long as the gyroscope is in action. The diagram, Fig. 6, has been obtained in a much higher sea with occasional very steep waves, which have evidently not been fully mastered by the apparatus, as on one occasion the remaining angle of roll exceeds five degrees to one side; however, the results may still be called satisfactory.

The experiments have shown that the "Seebar" is kept sufficiently steady when either drifting or steaming in a sea of about five feet average height, with occasional waves up to eight feet high. This result is very encouraging with regard to the application of gyroscopes to large vessels working in comparatively longer and higher waves, and it may be reasonably expected that a wheel about 6 feet in diameter, running at 1,400 revolutions per minute, would keep a vessel of 2,000 tons displacement, with a moderate metacentric height, steady in any sea that is likely to be encountered. The metacentric height is of first importance, as the size of the machine increases very much with the item. In steam yachts, pleasure and Channel steamers, which come principally in question for the application of gyroscopes, the metacentric height can be kept small, and, in any well-designed vessel, is kept as small as possible, on account of the advantages pointed out above, but there seem to be still many ships afloat where not enough attention has been paid to this important matter.

The first practical application of Schlick's gyroscope will be made in Germany. The Vulcan Works in Stettin have recently finished the apparatus intended for the Hamburg-America Company's vessel "Silvana," a pleasure steamer of about 900 tons displacement. This gyroscope is steam-driven and similar in design to that on the "Seebar;" the flywheel is 63 inches in diameter, and designed to run 1,800 revolutions per minute. The shop tests carried out with this machine a few weeks ago have given entire satisfaction, and the apparatus will begin its duty at sea very shortly.

The Tyneside Company have also commenced the manufacture of Schlick's gyroscopes at their Neptune Works. The design of their machines is somewhat different from the above. The flywheel is driven by an electric motor fitted on the same shaft. The brakes are not hydraulic, but friction brakes of a special design, and various other modifications have been introduced in order to produce standard machines of a compact, simple, and efficient type.

One apparatus for a pleasure steamer of 500 tons displacement is now nearly completed, and it is expected that, in Great Britain as well as in Germany, ships fitted with steadying apparatus will be in service very shortly.

MODERN THEORIES OF ELECTRICITY AND MATTER.*

BY MADAME CURIE.

WHEN one reviews the progress made in the department of physics within the last ten years, he is struck by the change which has taken place in the fundamental ideas concerning the nature of electricity and matter. The change has been brought about in part by researches on the electric conductivity of gas, and in part by the discovery and study of the phenomena of radioactivity. It is, I believe, far from being finished, and we may well be sanguine of future developments. One point which appears to-day to be definitely settled is a view of atomic structure of electricity, which goes to conform and complete the idea that we have long held regarding the atomic structure of matter, which constitutes the basis of chemical theories.

At the same time that the existence of electric atoms, indivisible by our present means of research, appears to be established with certainty, the important properties of these atoms are also shown. The atoms of negative electricity, which we call electrons, are found to exist in a free state, independent of all material atoms, and not having any properties in common with them. In this state they possess certain dimensions in space, and are endowed with a certain inertia, which has suggested the idea of attributing to them a corresponding mass.

Experiments have shown that their dimensions are very small compared with those of material molecules, and that their mass is only a small fraction, not exceeding one one-thousandth of the mass of an atom of hydrogen. They show also that if these atoms can exist isolated, they may also exist in all ordinary matter, and may be in certain cases emitted by a substance such as a metal without its properties being changed in a manner appreciable by us.

If, then, we consider the electrons as a form of matter, we are led to put the division of them beyond atoms and to admit the existence of a kind of extremely small particles, able to enter into the composition of atoms, but not necessarily by their departure involving atomic destruction. Looking at it in this light, we are led to consider every atom as a complicated structure, and this supposition is rendered probable by the complexity of the emission spectra which characterize the different atoms. We have thus a conception sufficiently exact of the atoms of negative electricity.

It is not the same for positive electricity, for a great dissimilarity appears to exist between the two electricities. Positive electricity appears always to be found in connection with material atoms, and we have no reason, thus far, to believe that they can be separated. Our knowledge relative to matter is also increased by an important fact. A new property of matter has been discovered which has received the name of radioactivity. Radioactivity is the property which the atoms of certain substances possess of shooting off particles, some of which have a mass comparable to that of the atoms themselves, while the others are the electrons. This property, which uranium and thorium possess in a slight degree, has led to the discovery of a new chemical element, radium, whose radioactivity is very great. Among the particles expelled by radium are some which are ejected with great velocity, and their expulsion is accompanied with a considerable evolution of heat. A radioactive body constitutes then a source of energy.

According to the theory which best accounts for the phenomena of radioactivity, a certain proportion of the atoms of a radioactive body is transformed in a given time, with the production of atoms of less atomic weight, and in some cases with the expulsion of electrons. This is a theory of the transmutation of elements, but differs from the dreams of the alchemists in that we declare ourselves, for the present at least, unable to induce or influence the transmutation. Certain facts go to show that radioactivity appertains in a slight degree to all kinds of matter. It may be, therefore, that matter is far from being as unchangeable or inert as it was formerly thought; and is, on the contrary, in continual transformation, although this transformation escapes our notice by its relative slowness.

In the beginning of the last century Coulomb and Ampère regarded each of the two kinds of electricity to be a fluid under the influence of central forces—repulsion existing between particles of the same fluid and attraction between particles of different fluids. Such forces would be proportional in the electric charge of the particles, and would vary in inverse ratio to the square of the distance between them. Starting with these hypotheses, and explaining suitably the observed facts relative to the different nature of conductors and dielectrics, they constructed a very perfect theory of electrostatic phenomena. An analogous theory for magnetism may be built up by assuming that the law of action between two magnetic poles is absolutely like the law of action between electrified particles. The electric current was regarded as the flowing of an electric fluid in a conductor. To establish a theory of electro-magnetics and electro-dynamic phenomena, it is necessary to bring in a third law of action-at-a-distance between the magnetic poles and the electric-current law of Laplace. All these theories in their entirety are founded on the laws of forces acting at a distance, in combination with the conception of electric fluids.

Faraday, although contemporaneous with this development, looked at the question from a different point of view. He did not believe in the possibility or power of action-at-a-distance between electrified bodies, and thought that the forces which were exercised between them resulted from elastic tensions which established themselves in the intervening medium. These elastic forces comprise a tension in the direction of the lines of force and a pressure at right angles to them. In seeking to show the direct influence of the medium he was led to the discovery of the inductive power of dielectrics, and his belief in the essential

* Abstracted from a lecture. Translated, by permission, from Revue Scientifique, Paris. Fifth series, Nos. 20, 21, Vol. vi., November 17 and 24, 1906.

part played by the intervening medium was thus strengthened. According to Faraday, the surfaces of charged conductors are to be regarded as surfaces of separation between regions where an electric field exists and fields of zero intensity. He was struck by the barrenness of the efforts that had been made to realize an absolute charge, and electric charges always appeared to him as the ends of tubes of force which traverse the dielectric.

Maxwell, captivated by the ideas of Faraday, endeavored to explain them in mathematical language. He demonstrated that there does not exist in a mathematical view any incompatibility between theories based upon laws of action-at-a-distance and Faraday's theory of continuous action; and that by assigning a reasonable value to the tensions and pressures which Faraday conceived to exist in the dielectric, an electrostatic theory could be constructed identical to that which is derived from the law of action-at-a-distance. While Maxwell does not specify precisely the nature of electricity, he treats of it generally as a fluid whose displacement in a conductor gives rise to a resistance proportional to the velocity of the flow, while its displacement in a dielectric produces an elastic reaction. In a dielectric, displacement can only occur at the time when the field changes. One of the essential ideas of Maxwell was to consider the displacement of electricity in the dielectric as an electric current to which he gives the name of "currents of displacement." Currents of displacement, according to Maxwell, behave like ordinary currents, in the sense that they produce magnetic fields. Every open circuit in a conductor, following the opinion of Maxwell, is completed by a current of displacement in the dielectric, so that there exist only closed circuits.

The system of the six differential equations, called Maxwell's equations, brings out in mathematical form the relation which exists at each point of an electromagnetic field between the current of displacement and the magnetic field, as well as between the rate of change of the magnetic induction and the resulting electric field. These perfectly symmetrical relations show that all variations of an electric field cause a magnetic field, and *vice versa*. Starting from these equations, Maxwell proved that every perturbation of an electro-magnetic field should be propagated in a vacuum, with a velocity equal to that of light in a vacuum, and he draws the conclusion that the medium which transmits electro-magnetic actions in the vacuum is the same as that which transmits light, and that light is very likely an electro-magnetic phenomenon. This conception has served as the basis of the electromagnetic theory of light, now universally adopted as the result of the experiments of Hertz and numerous physicists upon the electro-magnetic waves. In the development of the ideas of Faraday and Maxwell, a preponderating influence was attributed to the rôle of the dielectric medium, so that little attention was paid for some time to the nature of electricity; and this question was relegated to a subordinate place, and received only an indirect interpretation. There was no longer the conception of charges of electricity localized in a determined region, nor of a fluid flowing through a conductor. The main conceptions were of energy localized in the dielectric medium and the differential equations which determined the field in the medium. Recent progress in research has brought us back to a more concrete conception of the nature of electricity.

The first impulse in this direction was the result of investigations of electrolysis and modern theories of this phenomenon. It was established with certainty that the passage of electricity in the electrolyte is always accompanied by the transportation of matter. Electrolytes are aqueous solutions of acids, bases, and mineral salts, or these bodies in a fused condition. It is now admitted that the molecules of a dissolved substance are totally or partially dissociated in two ions—one ion formed by the metal, or hydrogen, and charged positively; another formed by the acid radical, and charged negatively. When there is set up in the solution an electric field the ions move toward the electrodes of contrary sign, transporting across the liquid their charges, which they give up to the electrodes, and themselves become free in a neutral state. Ions are, then, the actual carriers of electricity in electrolytes, and the current is a current of convection. It follows from Faraday's laws that all monovalent ions carry the same amount of charge, q, corresponding to 96,600 coulombs per gramme of ions, while an ion of valence, n, carries a charge nq. There cannot be conceived in electrolysis an isolated charge of electricity less than that carried by a monovalent atom, such, for example, as hydrogen in the ionic state. The atomic structure of electricity is therefore an immediate and necessary consequence of the atomic structure of matter.

It is by no means evident, *a priori*, that this conception can be generalized and that the other known cases of conduction are susceptible of an analogous interpretation; but this seems to be coming to pass. The study of the electrical conductivity of gases has borrowed from the theory of electrolysis the idea of charged ions, vehicles of the current; and the phenomena are satisfactorily accounted for by the hypothesis that the current in a gas is a current of convection. But the vehicles of the current are not here the same as in an electrolyte. It is believed that an ionized gas gives rise to two ions, of which one is that minute thing which we call an electron, the other being the remainder of the molecule deprived of the electron. By ingenious methods the number of ions present in a given volume of gas has been counted and the charge carried by each one determined. This charge is equal to that transported by an atom of hydrogen in electrolysis, and thus we find this presented to us the second time as the smallest quantity of electricity which can be isolated.

All the phenomena of conduction across a gas under the influence of different forms of radiation or in the disruptive discharge at varying tension appear to be susceptible to explanation by the theory of the ionization of gases.

Attempts have been made to explain the conduction of metals in a similar way, and it is probable that this also may be considered as a current of convection whose vehicles are the electrons set free in the metal. Thus we arrive at the conclusion that electric currents through all forms of matter are currents of convection, or, in other words, the displacements of electric charges. Besides this it has been proved that any such displacement gives rise to a magnetic field.

The conception of the existence of atoms of electricity which is thus brought before us in the phenomena of conduction plays an essential part in modern theories of electricity like that of Lorentz. This theory retains the fundamental idea of Faraday and Maxwell, according to which the electromagnetic actions are always transmitted from place to place in a continuous medium with a finite velocity. This medium is the ether of space, and the velocity is the velocity of light. The laws of variation of an electromagnetic field in the ether are expressed at each point by the equations of Maxwell, and the causes which produce the electromagnetic field are sought in the existence of positive and negative atoms of electricity and in the motions of these atoms. We are thus returning to a conception which recalls the old idea of two electrical fluids, only that we distinguish clearly the atomic structure of these fluids, and we understand better the relations which exist between the atoms of electricity and matter, a relation which is the most important aspect of the problem.

An atom of electricity in motion produces around itself an electromagnetic field which accompanies the movement of the particle, and which represents a certain quantity of energy whose amount is greater the higher the velocity of the charged projectile. It is not possible to increase this velocity without the expenditure of energy, and in consequence the charged projectile is endowed with a certain inertia. In mechanics inertia is used as a measure of the mass, and we may say that the atom of electricity possesses mass on account of its charge. Computation shows that the mass depends upon the velocity. It remains constant when the velocity of the projectile is small (about one one-hundredth the velocity of light), but for increasing velocities it augments very rapidly and tends toward an infinite value when the velocity approaches that of light, so that this is a limiting velocity which cannot be realized.

It may be imagined that a group of atoms of electricity, both positive and negative, whose total charge is zero, possesses, nevertheless, inertia in consequence of the constituent electrical charges. This group might serve as a model of a material atom. Thus may be proposed a more general form of mechanics than that customarily considered, which is based on the constancy of mass. The latter would be no more than a first approximation to the truth, and holds good only for cases of motion where the velocity is not extremely great. Preliminary attempts have been made to explain universal gravitation between atoms constituted as above proposed. Altogether these studies tend toward an intimate fusion of the idea of electricity and the idea of matter, so that these two conceptions may yet be actually identified.

This proposed constitution of the atoms serves as an excellent foundation for a theory of the emission of light or radiation by a body. Such emission may be regarded as consisting of electro-magnetic waves of short period, emitted by an atom whose constituent ions are in a state of vibration. The same atomic structure serves also very well in the case of radioactive atoms. These atoms are in fact emitting corpuscles, some of which are electrons, others positively charged particles having a size comparable with that of atoms.

But we will not now penetrate further the domain of these theories, but turn rather to examine some of the phenomena which have served as a foundation for their development. It is well known that gases in their ordinary state, when exposed to a weak electrical field have so insignificant a conductibility that they are regarded as remarkably good insulators. But it is not the same when the gases are under the influence of certain exterior conditions, as, for example, the Roentgen rays, for in such conditions a gas becomes conducting. A charged electroscope in connection with a metallic plate in ordinary circumstances loses its charge but slowly. If, however, a stream of Roentgen rays penetrates the air around the plate, the discharge proceeds rapidly. It is not necessary for the Roentgen rays actually to strike the plate, but suffices that the air be traversed within a distance where the electric field is still sensible. This is shown by constraining the Roentgen rays to follow a tube impenetrable to them, and thus shielding the plate from their path, so that it is certainly the gas which is modified and rendered conducting. We say that the gas is ionized, some of its molecules having been decomposed by the rays, and that each of these has given rise to the formation of two ions laden with equal electric charges having opposite signs. The ions are put in motion under the influence of the electric field with a velocity which increases with the strength of the field. If the electroscope is charged positively, the negative ions are drawn toward and discharge it, while the positive ions go in the opposite direction and neutralize the charge found at the extremities of the lines of force which emanate from the plate.

If the gas which has been under the influence of the rays is left to itself without the action of any electric field to move the ions, its conductivity disappears spontaneously, and we say that the ions have recombined to form neutral molecules.

There appear to be in the gas movable charged centers, which travel toward the plate of the electroscope. These centers may be intercepted by means of a screen of paraffin. The screen should not itself be charged, as may be tested by means of a second electroscope. The positive charged plate of the first electroscope may now be covered with the screen, and the Roentgen rays then allowed to act for a time. Negative ions moving toward the charged plate are arrested by the paraffin, and they charge the screen negatively. This may be verified by again bringing the paraffin screen near the second electroscope.

It may be shown that under the action of the Roentgen rays the number of ions produced in a gas in given time is definitely limited.

The rate of discharge of the electroscope is measured by the rate of fall of the gold leaves; and it increases with the electric intensity of the charge, as may be easily understood. Therefore, the stronger the electric field and the greater the velocity the less is the chance that the opposite ions draw together. But for a charge sufficiently great, the rate of the discharge no longer depends on the amount of the charge and does not increase as it augments. Under these circumstances there are no longer any recombinations of ions; they are all utilized for conducting the current, which cannot exceed what they can carry. Such a current is called a current of saturation. It is constant for a given intensity of radiation independent of the sign of the electric charge.

An important difference shows itself between the properties of positive and negative ions. This difference is easily shown by the gases of flames. These gases are ions and conductors, and the approach of flame promotes the electric discharge. Contact with the flame is not necessary. It is sufficient that the ions are produced within the region covered by the electric field. The attraction of the charge of the electroscope suffices to draw from the flame the ions of contrary sign, which neutralize it, and this phenomenon takes place, whatever the sign of the charge. But an isolated flame placed between the two plates of a charged condenser inclines toward the negative field; hence we conclude that the flame is then charged positively. This is because the negative ions produced in the flame are smaller and by far more active than the positive ions, so that they are more easily drawn from the flame, and thus there is left with it an excess of positive electricity. In a cold gas the positive and negative ions have a nearly equal mobility, which is less than that found in a warm gas. They are thought to be in this case formed by the agglomeration of molecules grouped by electrostatic attraction about the charged centers. The dissimilarity between positive and negative ions manifests itself in certain cases even in their formation. This is shown, for example, in what is called the phenomena of Hertz: Certain negatively charged metals, such as zinc, lose their charge when illuminated by ultraviolet light, but if the charge is positive the illumination produces no discharge. It seems to be proved now that zinc and some other easily oxidizable metals have the property of spontaneously giving off electrons under the action of ultraviolet rays. If the emission is given off in a vacuum the electrons are able to acquire a very high velocity in an electric field, and they comport themselves then like the cathode rays of Crookes tubes. If the emission takes place in the air at ordinary pressure the electrons

surround themselves with agglomerations of neutral molecules, and form ions of little activity, like those ions which are formed in the air by the Roentgen rays. But in either case the discharge is non-reversible and takes place only if the metal is negatively charged, for the metal is not able to emit negative electrons if the departure of them is obstructed by the attraction of a positive charge residing upon the metal.

(To be continued.)

ELECTRICAL NOTES.

The deflection of a new oscillograph invented by J. T. Irwin depends on the difference in the temperatures of two wires. The instrument is polarized from a source of constant current and when the heat capacity of the wires is compensated for, by a condenser or inductive coil, it can be arranged to measure the instantaneous potential across two points of the current flowing in a circuit. It can also be arranged to measure the instantaneous power being given to a circuit.

Motors for steel mills are generally rated on the ½ hour full load 40 deg. C. temperature-rise basis. For given applications they should be chosen by determining the average losses for a cycle of operations, and comparing these with the losses different motors will stand with a satisfactory increase in temperature. The maximum temperature is one element in limiting motor capacity, and the temperature of the place where the motor is installed must be carefully considered; in making these comparisons the maximum torque, etc., required at any time must be considered. A voltage of 220 has been used more often than any other and may almost be considered a standard; the danger of a shock from grounding a 500-volt circuit has generally been a strong argument against this higher voltage. These general features can be applied to alternating-current motors. The split frame is very seldom used with these motors, however, and the brackets are made in such a way that they can easily be removed and the armature slid out of the frame along the direction of the shaft. In such a motor it is advisable to have split brackets, and the bearings should be separate from the brackets to give access to any part of the machine. The use of the electric drive to all the auxiliary apparatus in iron and steel mills, partly described above, has been gradually increasing since 1892. The drive of the main rolls has been a more difficult problem on account of the size of units and character of the load, and such installations are only of comparatively recent date; they are, however, of great importance and interest and are attracting the attention of both engineers and manufacturers.

Rock salt which is used for the electrolytic preparation of bleach liquors is liable to considerable variations in composition and the impurities exert an important influence on the results. During the electrolysis certain harmful secondary reactions may go on, which may be classed under two heads: formation of chlorate and reduction. The formation of chlorate may be either indirect, owing to the oxidation of the hypochlorite, or direct, according to the equation $Cl + 5OH = HClO_3 + 2H_2O$. The indirect formation of chlorate may occur in small plants where the circulation is deficient, e. g. in laboratory electrolyzers. The direct production of chlorate has been studied by A. Ahlin in the case of Schuckert's apparatus. According to an article of his in Papier Zeit., reduction takes place by a reconversion of hypochlorite into chloride, and occurs when the hypochlorite already produced comes in contact with the hydrogen from the cathode. It is prevented by the formation of a protective "diaphragm," consisting of sparingly soluble basic deposits on the cathode, produced by impurities in the salt solution. The work of each electrolyzer should be checked by drawing a curve with chlorine strength as ordinates and the times of electrolysis as abscissæ. Such curves will show when any of the electrolyzers is not giving normal results. Constant attention must be devoted to the temperature and the alkalinity of the liquor. The former should be low, and the latter should be such that 1 liter of the salt solution, when reddened with phenolphthalein, is decolorized by 2 drops of N/[illegible]-acid. This alkalinity is to be neutralized before the liquor is used for bleaching. The presence of magnesium chloride is objectionable, since it forms heavy deposits on the cathodes which impede circulation and create electrical resistance; it is removed by the addition of alkali as specified above. The only difference between the electrolytic bleach liquor and ordinary bleach liquor is the slightly more rapid action of the former; the consumption of chlorine for a given amount of bleaching work done is very slightly lower on this account. In Ahlin's opinion no electrolyzer gives really satisfactory results unless the anodes, at least, are of platinum. The consumption of platinum depends on the construction of the apparatus; it may be either mechanical, through the friction of solid particles suspended in an imperfectly filtered liquor, or electrical, increasing with the current density. The Schuckert apparatus is very economical in this respect; so long as the platinum has a smooth, clean surface no waste takes place, this only beginning when the surface gets rough.

SCIENCE NOTES.

The American Museum of Natural History is to have a novel representation of the bottom of the sea, showing coral reefs in all stages of development. The section of the floor to be cut out will be 6 x 30 feet. The task is a very delicate and tedious one, and it will require six months for completion.

Mr. S. D. Chalmers recently exhibited to the Royal Society some models illustrating refraction at plane and spherical surfaces. These models illustrate the influence of reduced velocity in glass on the form or direction of waves. The curvatures of the incident and refracted waves are indicated by flexible rods; the paths from a point on the incident to the corresponding point on the refracted wave are indicated by cords of constant length. To secure the effect of refraction the cords pass three times across the glass space and twice through the air space. On giving any suitable curvature to the incident wave the corresponding curvature of the emergent wave is obtained.

Tannisol is a methylditannin obtained by the action of formalin on tannin. The two substances are heated together on the water-bath, when effervescence occurs, and a viscous mass is formed. This is dried, powdered, and exposed to a temperature of 45 deg. to 50 deg. C., to drive off excess of formaldehyde. It forms a red-brown, odorless, and tasteless powder, insoluble in most solvents, except alcohol and dilute alkalies. It is prescribed in intestinal catarrh as an astringent antiseptic, in doses up to 8 grains for adults, or 1½ to 4 grains for children. It is also used externally as a dusting powder, either alone or combined with other powder, or in the form of a 10 per cent ointment or soap.—Nouveaux Remedes.

The researches of E. Pinoy, embodied in a thesis, show that the development of *Dictyostelium mucoroides* is dependent on the presence of certain bacteria. Even germination cannot take place in their absence. Cultures that appear pure are where the bacteria have disappeared, as the latter do not remain during the development of the *Dictyostelium*. The association of bacteria has been shown to be necessary in the case of three species of the Acrasieae, two of the Endomyxeae, and for *Plasmodiophora brassicae*. The Myxomycetes are parasitic on colonies of bacteria. In the plasmodial condition the constituent amoeboid bodies of the myxomycete absorb and digest the bacteria in their vacuoles, by the aid of an enzyme somewhat similar to starch diastase. The Myxomycetes induce certain biological changes in the associated bacteria; *Bacillus fluorescens*, var. *liquefaciens*, loses the power of causing fluorescence in a nutritive solution or on gelatine. The pigment of certain bacteria impregnates the protoplasm of the myxomycete during certain periods of development, and it is difficult to distinguish between the true coloration of a plasmodium and the color imparted by the bacteria.

In the course of a lecture delivered before the Royal United Service Institution in London, Col. Maude, late R. E., in the course of his remarks pertaining to the question of health in tropical climes, pointed out the relation between actinic rays and their effect upon the great nerve centers running down the spinal column. If these rays are excessive the disturbance of the nerve centers reacts upon the stomach, upsetting digestion as well as provoking the dangerous malady of sunstroke. Consequently, it is obvious that if a non-actinic material were used next to the skin the effect of the actinic rays would be nullified. Col. Maude personally tried the experiment some twenty-five years ago, and the relief thus secured was remarkable, since he was able to prosecute his duties in the hottest sun without inconvenience or experiencing any ill effects. The same phenomena have been observed by other sufferers, who by lining their wearing apparel and also their helmets with a red fabric have secured instant relief from the afflictions incidental to working in a torrid, blazing sun. Under these circumstances it is somewhat strange that our manufacturers have not seized the opportunity and produced various textiles answering these requirements. Even red shirts are not readily obtainable, and that distinct benefits accrue from their use is borne out by the experiences of friends of the writer, who, when engaged upon the shadeless plains of Nevada, in the United States, where the summer temperature is sufficient to raise iron to an unbearable heat, yet suffer no bodily pains, though they pursue their tasks for hours on end in the broiling sun. Considering the exodus to the tropical climes of India and Africa steadily goes on from year to year, with a corresponding demand for clothing adapted to such regions, there should be a ready and profitable trade in non-actinic clothing such as is possible by the use of red lining.

TRADE NOTES AND FORMULÆ.

To Pevent Dry Rot.—Mix 950 parts by weight of boracic acid, 5 parts of paraform, and 5 of green vitriol. Pour the mixture into 4,000 parts of boiling water and spread over the wood with a brush.

Resinous Safety Ink.—Add 10 parts each of pine resin and crystallized soda to 100 parts of water and boil till a clear solution is obtained. To save time, a mixture of 7 parts of soda and 3 parts of soda lye may also be used. Then rub together 4 parts of rubber and 2 parts of lampblack, dilute with water, and add the mixture to the resin solution.

A New Mass for Molding.—A mass for molding, according to a process patented by Heinrich Sommer of Grünberg, in Silesia, can be prepared by first making a mixture of about 2/5 chalk, rather more than ½ burnt gypsum, and a small quantity of zinc white, then a second mixture of 1/3 boiled linseed, 1/5 poppy oil, 1/5 varnish, 1/5 strongly hydrated boiled glue, about 1/10 to 1/12 chalk with a small addition of zinc white and gypsum, and combining these two mixtures before use in the proportion of 2:1 or 3:1.

Bactericide Paint for Micro-organisms and Parasites of Plants.—This paint, which may be used alone or with any other paint, consists of 5 to 6 per cent solution of a salt of cresol-sulphonic acid. As such solutions can be relied upon for destroying micro-organisms such as fermentation and mold fungi, they can be used with advantage in all rooms in which it is important to keep the atmosphere free from bacteria, e. g., in breweries, spirit distilleries, sugar factories, etc. In view of the efficacy of the solutions of the salt of cresol-sulphonic acid for destroying the eggs and larvæ of insects injurious to plants, it is advisable to use them for sprinkling and watering plants exposed to the ravages of such parasites. The solutions are free from odor; they are also non-volatile and non-corrosive.

French (Shellac) Polish Combined With Chalk.—These polishes, according to the Farben Zeitung, can be readily applied and are very useful for furniture which is not too much scratched; much worn surfaces must first be treated with chalk and afterward with the French polish. Most of the shellac (French) polishes on the market are to some extent colored by the shellac they contain, but in most cases they require to be brightened up with aniline dyes to bring out the desired characteristic color of the wood in polishing. To obtain a better distribution of the polish, some linseed oil or well-refined thin mineral oil is added to the French polish. A polish of this kind, for example, can be prepared by dissolving 5 parts by weight each of shellac and sandarac in 77 parts by weight of 95 per cent alcohol, filtering, and adding 8 parts by weight of mineral oil and 8 of Spanish white; this French polish can be dyed additionally with aniline dyes.

Resistive Photographic Aniline Prints.—A new process for reproducing drawings, etc., by making photographic prints impervious to the action of sunlight, acids, and lyes has been worked out by C. Meissner. Paper, free from wood, should be evenly coated in a dark chamber under a red light with a mixture consisting of 1 part potassium bichromate, 10 parts distilled water, 10 parts phosphoric acid—1.124—and dried there. This sensitive paper is then exposed to the light under a drawing till the pictures can be plainly seen in yellow lines on a white or pale green ground—4 minutes in the sun, 30 to 40 minutes in diffused daylight. The copy is now suspended in the smoke chamber—a flat box of suitable size—in such a manner that it does not touch the felt strips at the bottom. One of these strips is moistened with water, the other with a solution of 1 part of aniline in 16 of benzole. The development of the picture in the smoke box takes 10 minutes; when the drawing appears sufficiently dark, the picture is taken from the box and placed in water. If 1 per cent of sulphuric acid is added to the water, a greenish black shade will result; if 5 per cent of ammonia solution, a violet shade will be obtained. As soon as the required shade has been obtained, the picture is placed in water, frequently renewed, and then dried in the air.

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